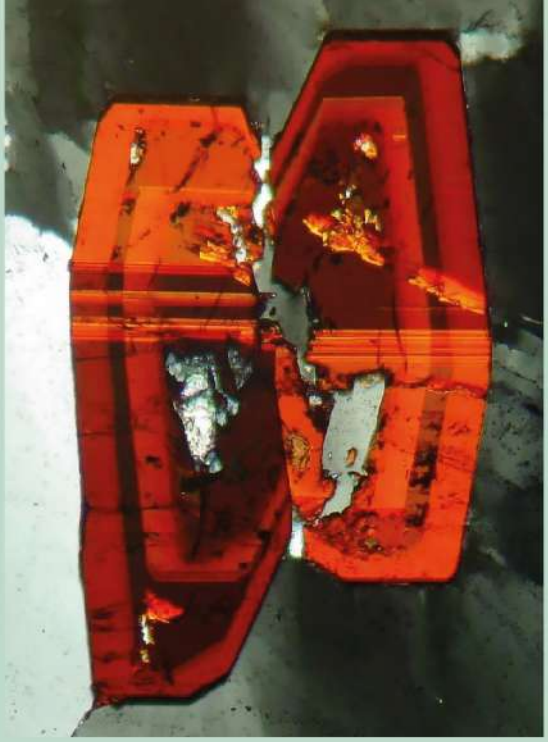

QUADERNI, 47

THE MANGANESE MINE OF PRABORNA (AOSTA VALLEY, ITALY)

AN OPEN-AIR MINERALOGY MUSEUM AT THE ORIGIN OF RENAISSANCE VENETIAN CRISTALLO

By
GASTON GODARD
SILVANA MARTIN
SIMONE TUMIATI

ACCADEMIA · DELLE · SCIENZE · DI · TORINO
VERITAS ET UTILITAS

QUADERNI, 47

This volume was funded by the Dipartimento di Geoscienze, Università di Padova, with additional funding from the Dipartimento di Scienze della Terra "Ardito Desio", Università degli Studi di Milano.

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ISSN: 1125-0402 | e-ISSN: 2974-797X
ISBN: 978-88-99471-63-7

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Accademia
delle Scienze
di Torino
1783

PRESENTATION

The ancient manganese mine of Praborna, located in the upper valley of Saint-Marcel in the Aosta Valley Region (North-Western Italy), was first documented in 1402. Its manganese-rich ore was used by the Venetian glassmakers to decolourise precious *cristallo* glass, which was then used in Murano (Venice) to make luxury artefacts and mirrors until the introduction of lead-based glass at the end of the 18th century.

Galileo also used it to make transparent lenses for his telescopes. By adding powder of the Mn-rich ore from Praborna to their glass, the Venetian glassmakers unknowingly applied a simple chemical reaction that cancelled the greenish colour caused naturally by ferrous iron, rendering the glass transparent: Fe^{2+} (greenish, in glass) + Mn^{3+} (added) → Fe^{3+} (colourless) + Mn^{2+} (almost colourless). The Venetians guarded this knowledge jealously, but it finally spread throughout Europe during the 17th century, when «Piedmont manganese» (in fact, Praborna manganese ore) became widely used. In 1665, Jean-Baptiste Colbert, minister to Louis XIV, founded the *Manufacture royale des Glaces*, now known as the Saint-Gobain Company. Through espionage, the company managed to reproduce the Venetian technique. Consequently, the glass in the Hall of Mirrors at the Palace of Versailles probably contains a little of the Praborna manganese.

This ancient manganese mine is also world-famous in the scientific literature for its unique geological and mineralogical features. For example, Praborna is the type locality of four valid mineral species, namely piemontite, braunite, strontiomelane and manganiandrosite-(Ce). In addition, some peculiar Mn-bearing minerals have been first observed and described at Praborna: *alurgite*, a red-coloured, Mn-bearing variety of phengite; *greenovite*, a pink-coloured titanite; *roméite*, which gives its name to a mineral group; *violan*, a violet-coloured omphacitic clinopyroxene. Compared to other manganese deposits, that of Praborna is quite exceptional, since it displays an Alpine eclogite-facies metamorphic overprint. Furthermore, the ore exhibits a layered structure, with different levels displaying various bulk compositions and, thus, different mineralogical assemblages. In some localised domains, the concentration of peculiar elements (Sb, Cr, As, V, Ba, Sr, Au and REEs) has resulted in the formation of very unusual minerals. Notably, a Cr-rich emerald-green level contains interesting minerals such as native gold, vanadates,

https://doi.org/10.14672/QUAD2026-47-1

Cr-rich epidote, pyroxene and mica. Because of the highly oxidising conditions related to the abundance of the manganic ion (Mn^{3+}), sulphides are absent. Instead, chalcophile elements entered silicate and oxide minerals, forming rare minerals such as ardennite-(As), hydroxycalciоromeite, Sb-rich pyrophanite, Sb-rich rutile and titanite, and As-bearing apatite. In short, Praborna is an open-air museum of mineralogy and a never-ending source of petrological and mineralogical study.

We therefore invite readers to discover the unique history of Praborna. This memoir is divided into two main sections. The first part is devoted to the history of the «cristallo veneziano and Praborna mine», and the second part focuses on «Praborna, as a paradise for mineralogists». Useful information on abbreviations, units and mineral names can be found in the notes. At the end of the memoir, we present a Praborna-related bibliography containing some 300 references and 180 manuscript sources[1]. Finally, to conclude this presentation, we have included a map and photographs of the site.

We would like to thank the Accademia delle Scienze di Torino for organising a study day entitled «Il segreto del cristallo veneziano: la miniera di Praborna» in Turin on 23 April 2025[2], and for publishing this special issue of its *Quaderni*, 240 years after the first studies on Praborna were published in the Academy's *Mémoires* by Spirito Benedetto Nicolis de Robilant (1786, 1788) and Carlo Antonio Galeani Napione (1790)[3]. We would particularly like to thank the director of the *Classe di Scienze fisiche, matematiche e naturali* of the Academy, Professor Daniele Castelli, for his encouragement and

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[1] A book by Joseph-César Perrin about the history of the Praborna mine was published in early 2026. Unfortunately, we only became aware of it during the proofreading process, so we were unable to cite it in the text. Readers may wish to consult the book, particularly for its detailed history of the mine under the Challant family: J.C. Perrin, *La mine de manganèse de Prabornaz – Saint-Marcel – Histoire de son exploitation*, Edizioni Pedrini, Pont-Saint-Martin (AO) 2026, 300 pp.

[2] www.accademiadellescienze.it/iniziative/2025/il-segreto-del-cristallo-veneziano-la-miniera-di-praborna. The records of the oral presentations are available online at this address.

[3] S.B. Nicolis de Robilant, *Essai géographique suivi d'une topographie souterraine minéralogique et d'une docimasie des Etats du Roi de Sardaigne en terre ferme*, in «Mémoires de l'Académie royale des Sciences [de Turin]», années 1784-1785, 1786, pp. 191-304 [pp. 224, 263; pl. VI]; S.B. Nicolis de Robilant, *Description particulière du Duché d'Aoste, suivi d'essai sur deux minières des anciens romains, et d'un supplément à la théorie des montagnes et des mines*, in «Mémoires de l'Académie royale des Sciences de Turin», années 1786-1787, 1788, pp. 245-274 + pl. VII-IX; C.A. Galeani Napione, *Analyse de la mine de manganèse rouge du Piémont par M. le chevalier Napion*, in «Mémoires de l'Académie Royale des Sciences [de Turin]», vol. IX (1788-1789), 1790, pp. 303-308.

The authors at the entrance to the ancient Praborna mine on 15 July 2022 during the field trip that concluded the 14th International Eclogite Conference. From left to right: Gaston Godard, Simone Tumiati and Silvana Martin.

assistance, and Maria Filippi, who provided expert and patient editorial support. We would also like to thank everyone who contributed to this project, whether by lending us photographs or by making a financial contribution (see «Photo credits and contributions» in the «Notes» section). In particular, we would like to thank Raffaele Prete for kindly allowing us to reproduce some of the beautiful photographs of mineral samples from the Praborna mine, originally published in his 2024 book *Gemme e gioielli della miniera di Prabornaz*.

On 1 June 2026

Gaston Godard
Silvana Martin
Simone Tumiati

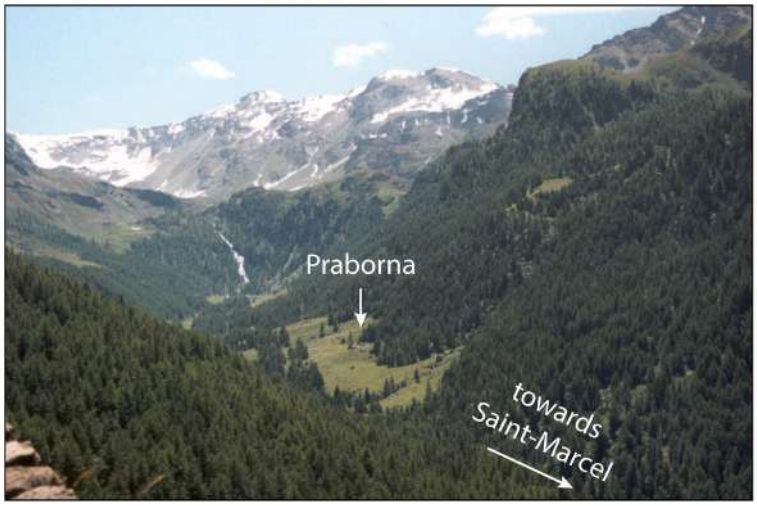

Figure P.1. The upper Saint-Marcel Valley looking south from the Servette copper mine.

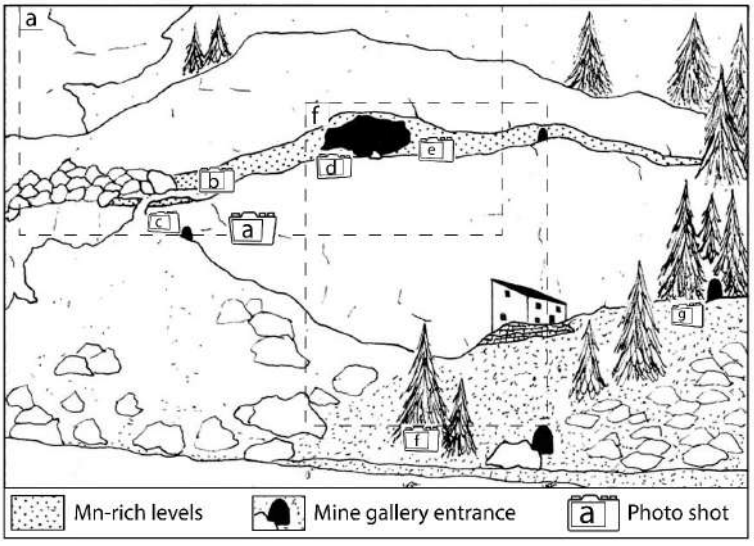

Figure P.2. View of the Praborna mine facing west in 1982, modified after Castello. Photographs a-f are shown in Figure P.3.

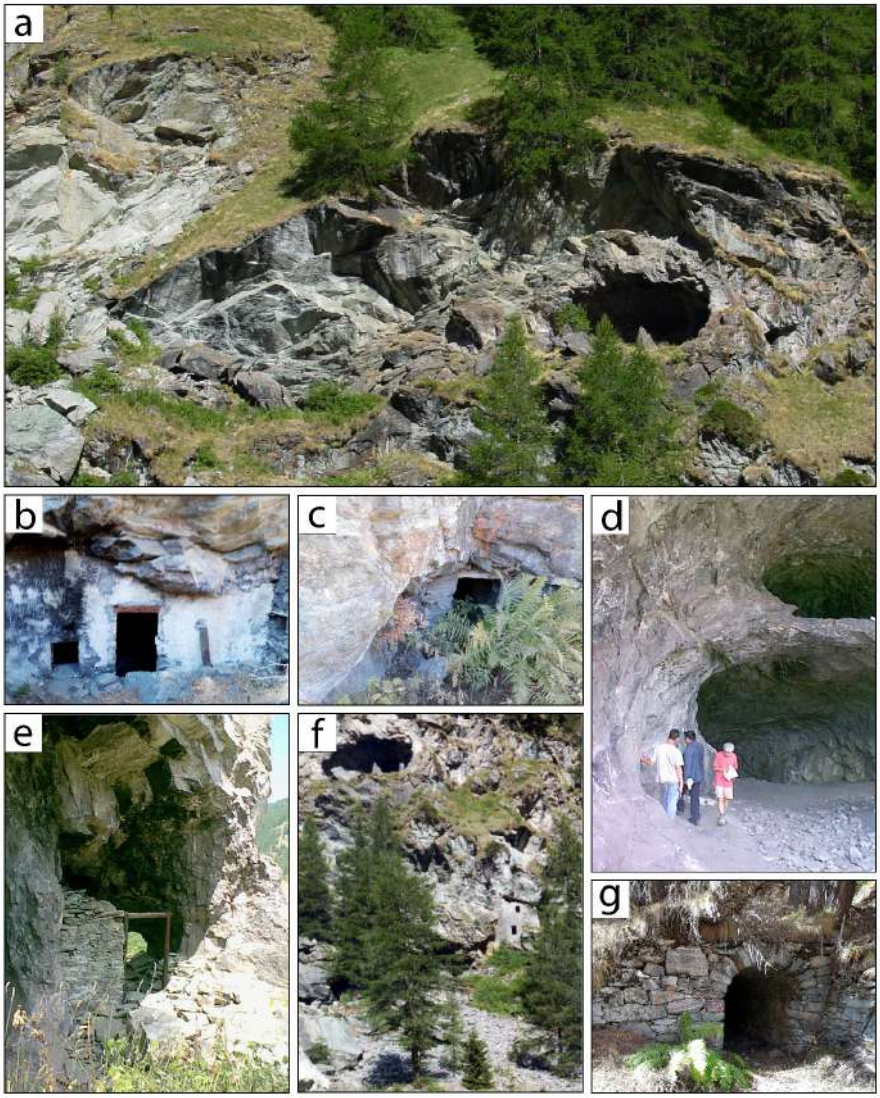

Figure P.3. Photographs of the Praborna mine in 2018.

The position of the views is shown in Fig. P.2. (a) General view towards the west. (b) Ruins of the workers' house (the remains of the collapsed Saint-Jacques galleries can be accessed behind the wall). (c) Lowest levels, with a gallery entrance dug into underlying glaucophanite. (d) Main entrance, with two superimposed cavities. (e) Entrance of *Cabinet Cavour*. (f) Main entrance (top left) and ruins of the foremen's house (on the right). (g) Entrance of the *Ribasso superiore* gallery.

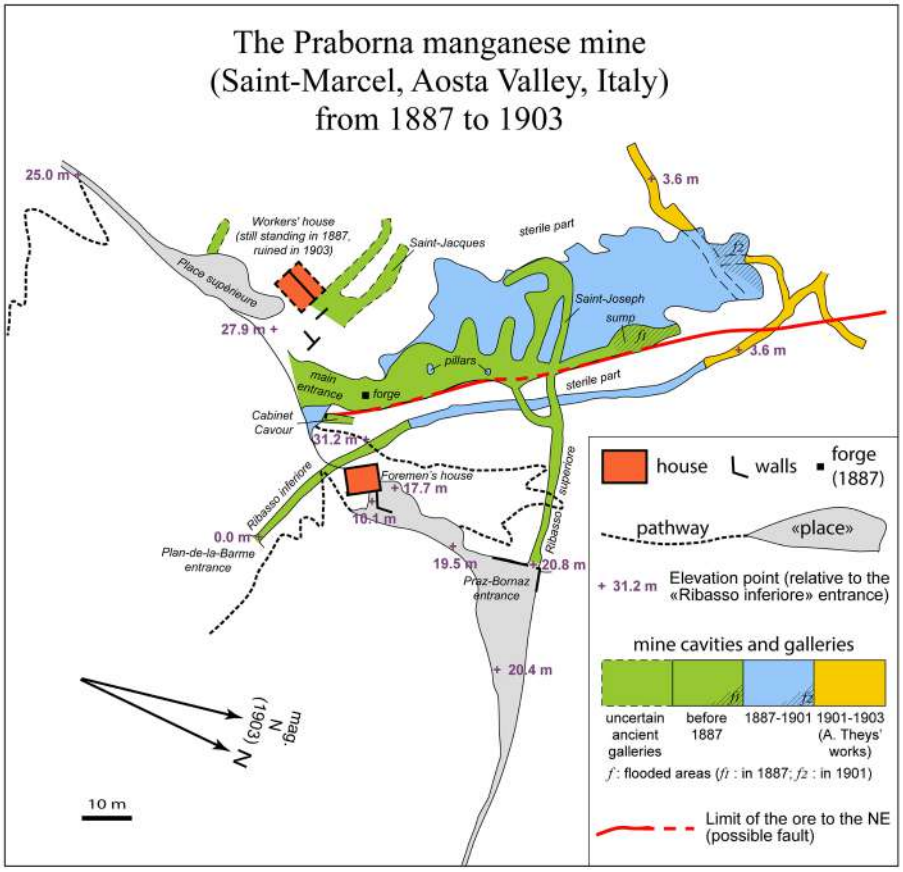

Figure P.4. The Praborna mine from 1887 to 1903.

This map was created based on mine plans from 1887 and 1903 (see Figs. 1.7 and 1.9). Where there was a discrepancy between the two plans, information from the more precise 1903 plan was given priority.

FIRST PART

THE *CRISTALLO VENEZIANO* AND THE PRABORNA MINE (15TH TO 20TH CENTURIES)

In this first part, we trace the history of the Praborna mine, first under the Challant family, who managed it for nearly four centuries, and then under the Bordon family after the Napoleonic period. We will then examine how the manganese trade was organised, which will lead us to Venice and Saint-Gobain, where manganese was highly prized for producing a perfectly transparent cristallo veneziano.

Chapter 1

History of the Praborna mine

Until the 18th century, the history of the mines in the Aosta Valley, particularly that of Praborna, was closely tied to the fate of the Challant family, who took possession of the Praborna mine in 1411. The Challant family are an illustrious feudal lineage who were very influential and powerful in the Aosta Valley until the French Revolution and the Napoleonic conquests. They were viscounts of Aosta during the 12th and 13th centuries, lords of Montjovet, Châtillon, Aymavilles, Graines, Ussel, Fénis, Saint-Marcel, etc., and became counts of Challant in 1424. They remained (fairly) loyal to their overlords of the House of Savoy for whom they performed numerous diplomatic and military duties. Some of them were also bishops or abbots[1].

The history of Praborna was marked by countless lawsuits relating to debts incurred or inheritance disputes between the different branches of the Challant family (Fig. 1.1), as revealed by the family archives. Although part of these archives was lost over time or burned by the municipality of Châtillon at the foot of the Tree of Liberty on 2 Ventose Year VII (20 February 1799), many have been preserved in the 342 remaining volumes of the Challant collection at the Archives of the Autonomous Region of the Aosta Valley, in Aosta[2]. They constitute an invaluable source of information on the history of mining in the region, before the Napoleonic period. These archives are sparse for the 15th and 16th centuries. They become more abundant between 1612 and 1670, during the dispute between the Perrone and Challant families over ownership of the Praborna mine, and further increase during the period 1671-1752 when the Challant family exploited the mine directly. The State Archives of Venice are another valuable source of information on the use of the Praborna

https://doi.org/10.14672/QUAD2026-47-2

[1] J.-B. de Tillier, *Historique de la Vallée d'Aoste par J.-B. de Tillier, secrétaire du Duché d'Aoste; manuscrit inédit de l'an 1742 […]*, Louis Mensio, Aoste 1887, 58-174-239-152 pp.; Id., *Nobiliaire du Duché d'Aoste*, edited by A. Zanotto, Ed. de la Tourneuve, Aoste 1970, 739 pp. + pl.; P. Durandard, *Histoire généalogique de la Maison de Challant – Ambitions et réussite d'un lignage féodal savoyard*, Cercle généalogique de Savoie, Annecy le Vieux 2019, 134 pp.

[2] J.-C. Perrin, *Inventaire des Archives des Challant*, in «Bibliothèque de l'Archivum Augustanum», I (tome 1), 1974; IV (tome 2), 1975; VI (tome 3), 1976; VIII (tome 4 + index), 1977.

«manganese» in Murano glassworks. Finally, the State Archives of Turin, the Haute-Savoie Archives in Annecy and the National Archives of France also provide information on the history of Praborna in the 19th and 20th centuries.

1.1 The Praborna mine under the Challant family (15th to 18th centuries)

The earliest mentions of the ancient manganese mine of Praborna date back to 1402, 1411 and 1415. It was cited in notarial deeds, which have since disappeared but are referenced in more recent documents, preserved to this day in the Challant family collection, in the Archives of the Autonomous Region of Aosta Valley (Italy). We present here these mentions translated into English, with the original texts in French, Latin or Italian provided in the notes:

«Bill of sale to the Lord Jaques de Challant by Aimonet and Vincent, sons of Marcel Paliet, and their uncle Maurizet, of a mountain located in the Rivier valley and called Pra Borna, registered by [the notary] Pierre Villard on 18 November 1411»[3].

«Bill of sale of the aforementioned mountain [of Pra Borna] by the Reverend George Guisiaco, priest of Saint-Marcel, to Marcel Palliet, son of Aimonet Paliet, from the locality of Saint-Marcel, registered by Jehan Charvery on 23 August 1402»[4].

These mentions indicate that the land of Praborna was sold to Marcel Palliet in 1402 by the priest of Saint-Marcel, who may have been acting on behalf of his parish. A few years later, in 1411, Praborna was sold by Marcel Palliet's sons and brother to Jacques de Challant. The identity of the buyer, «Jaques de Challant», is unclear; he may have been Jacquemin (Giacomino), one of Ebal II's sons and co-

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[3] «*Instrument de ve[nditi]on faicte au Seignieur Jaques de Challant par Aimonet et Vincent filz de marcel paliet et maurizet leur vncle d'une montaigne situee en la val de riuier appelle pra borna receu par pierre Villard lan mille quattre centz unze [1411] le dixhuictiesme [18] nouembre*.» (FC [Fonds Challant, Aoste] 55, 256r-256v). This deed was recorded by a notary named Pierre Villard. Villard is referenced in the Notarial Archives of Aosta («*tappa di Châtillon*») for the years 1506-1514, and signed at least six documents between 1503 and 1552, under the names of Pierre Villard and Pierre Villario. As the year 1411 in this document is written out in full, it is impossible to misread it. Therefore, assuming the name is correct, the notary from 1411 must be a homonym of the one from 1506-1514.

[4] «*Instrument de vendition faicte dicelle montaigne par ven[erable] george guisiaco Cure de Sainct marcel a feud a marcel palliet filz d'aimonet paliet endict lieu de sainct marcel receu par Jehan Charuery l'an mil quattre centz e deulx [1402] le vingttroysiemme [23] daoust*» (FC 55, 256v).

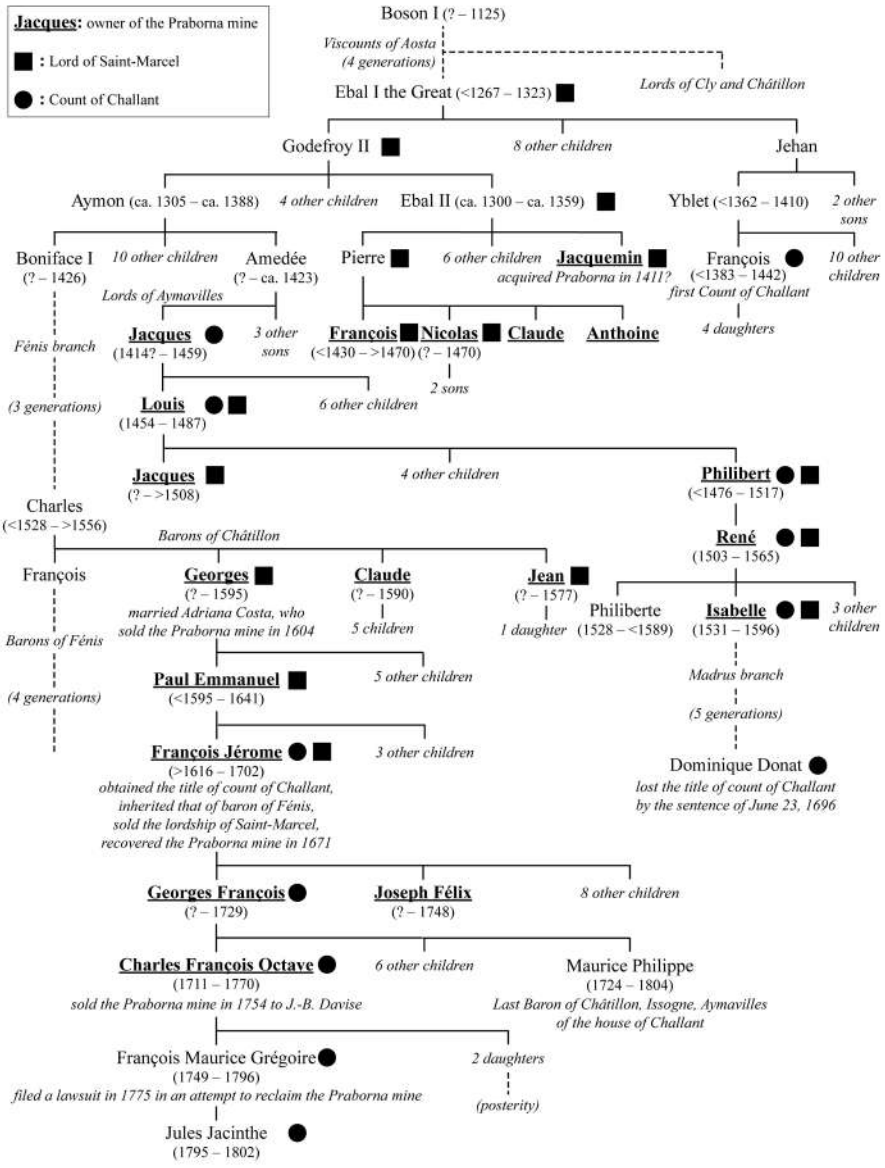

Figure 1.1. Simplified genealogy of the Challant family, showing the owners of the Praborna mine.

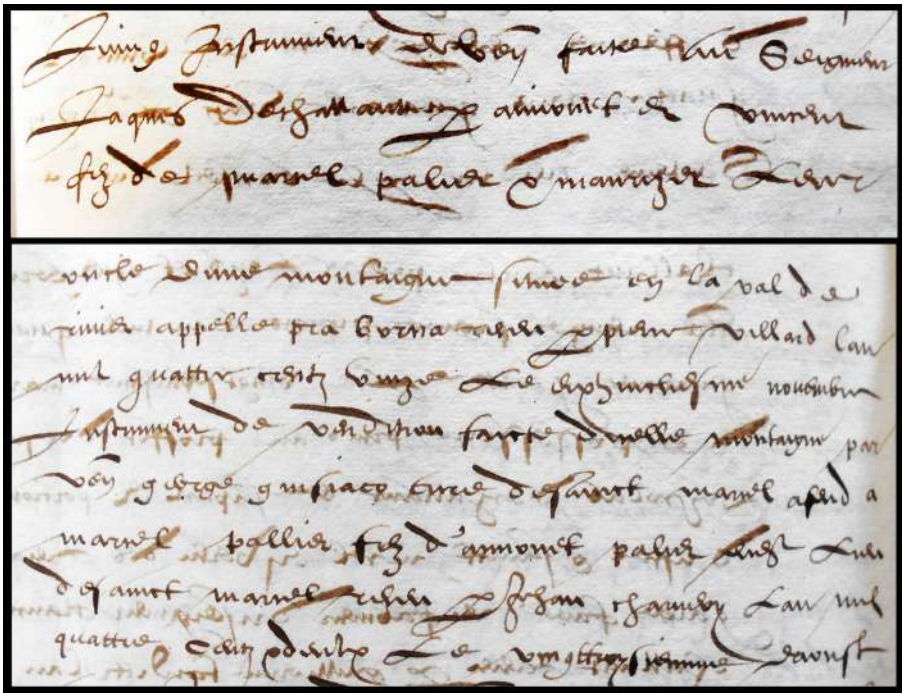

Figure 1.2. Oldest mentions of the Praborna mine (1402, 1411).

Details of folio 256 (FC 55), where the 1402 and 1411 documents are cited (please refer to the text for the English translation):

> «[*recto*] Instrument de ve[nditi]on faicte au Seignieur Iaques de Challant par Aimonet et Vincent filz de marcel paliet et maurizet leur [*verso*] vncle d'une montaigne situee en la val de riuier appelle *pra borna* receu par pierre Villard lan mille quattre centz vnze [1411] le dixhuictiesme nouembre.
>
> Instrument de vendition faicte dicelle montaigne par ven[erable] george guisiaco cure de Sainct marcel a feud a marcel palliet filz d'aimonet paliet endict lieu de sainct marcel receu p[ar] Jehan charuery l'an mil quattre centz e deulx [1402] le vingttroysiemme daoust».

lord of Saint-Marcel with his brothers (Fig. 1.1). Unfortunately, the original bills have been lost. These references, in old French language, appear in volume 55 of the Challant archives (ff. 256r and 256v; Fig. 1.2) and were transcribed by Justin Boson[5]. This volume contains an inventory of the Challant family archives, now largely missing, which was drawn up in French in 1565-1566[6].

A Latin manuscript dating from 1415 confirms that the Challant family owned Praborna and its manganese mine at the beginning of the 15th century. This was a donation act with enfeoffment made by Lord François (Francesco) de Challant, who was promoted to the title of first Count of Challant in 1424 by Amédée VIII of Savoy, with the approval of Emperor Sigismund. Written on 10 May 1415 at Châtillon, the document stipulates that various lands are to be donated to the brothers François (Francesco), Nicolas (Nicolao), Claude (Claudio) and Anthoine (Antonio), the sons of the late Lord Pierre (Pietro) de Challant, in exchange for 500 ducal gold florins. Among these lands was «the whole domain of Saint-Marcel, which Pierre de Challant formerly held and possessed at the time of his death and long before, and which he inhabited», with the «feuds, retrofeuds […], tolls, villages, watermills, all the mines called of Manganese and their pertaining lands, meadows, vineyards, trees [...] and all possessions [...]»[7]. The father of the legatees, Pierre, was one of the sons of Ebal II and the brother of Jacquemin, who was most likely the purchaser of Praborna. All of them were co-lords of Ussel and Saint-Marcel – titles that François and Nicolas inherited in 1430 and 1436[8].

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[5] J. Boson, *Inventaire des archives des châteaux de Challant [d'Aymavilles, Verrès, Ussel et Saint-Marcel, en 1565] extrait de l'original par le Chan. Prof Justin Boson […]*. in «[Bulletin de la] Société académique, religieuse et scientifique du Duché d'Aoste», vol. 22, 1929, pp. XXXIX-XLIV, 1-375 [p. 243, n° 539 and 540].

[6] The inventory was compiled by the notary Guillaume Carruczon de Carignan at the request of Isabelle de Challant, daughter of René (Renato), the 5th Count of Challant, who commissioned it for her dispute with her cousins over her father's inheritance.

[7] Copies in two 1670 documents (FC 162-5, ff. 23r-51v; FC 162-3): «[f. 23r] *In nomine domini Amen. Anno a nativitate ejusdem domini millesima quattercentesimo decimo quinto, indictione octava, die vero decima mensis Maii apud Castellione in valle Augustae infra castrum dicti loci videlicet in aula superiori dicti castri [... f. 31r] Item totam domum sancti Marcelli quam dictus Petrus de Challant quondam tempore sue mortis et diu ante tenebat et possidebat, et inhabitabat [f. 31v; cum...] predictorum feudorum, retrofeudorum directi dominii ipsone feudorum et retrofeudorum pedagiorum, vicorum, aquariciorum molendinum [f. 32r] omnium minerarum vocatarum de Maganesio et suarum pertinentiam terrarum, pratorum, vinearum, arborem [...] et omnium possessionem...*».

[8] L. Vaccarone, *I Challant e loro questioni per la successione ai feudi dal XII° al XIX° secolo*, F. Casanova, Torino 1893, in-4°, 58 pp.

We do not know how or when the manganese ore was first discovered, nor when its mining began. Since «Pra Borna» means the «meadow of the cave» in the Aosta Valley dialect[9], it is likely that caving had already begun by 1402, although this is not explicitly mentioned in the 1402 and 1411 documents, only in that of 1415. However, the testament in Latin of Ebal I, said the Great, on 24 May 1323 provides a *terminus post quem*: «The other heirs of the said Lord Ebal and their men may extract, by themselves or others, millstones from Saint-Marcel through the land and district of the said [heirs] Vullielmet, Yblet and Aymonet, at their own discretion...»[10]. This testament lists the properties of the Challant family and the economic activities in the territory of Saint-Marcel, including millstone extraction, traces of which can still be seen today in Fontillon[11]. Had the manganese mine been opened by 1323, it would most likely have been mentioned.

Whereas the date of the manganese discovery is uncertain, the location of the mine is not. Since the 15th century, it has been referred to in all documents as «Pra Borna» or «Pra Bornaz», «La Barme», «Barma» or «Barmaz», and it is located in the upper valley of Saint-Marcel (or San Marcello), also known as «Rivier» or «Revers» (Figs. P.1, 1.3).

In her extensively researched thesis, which she defended in 1929, Ernestina Dulio[12] emphasises the considerable privileges that the Challants enjoyed until the 18th century over the mines under their jurisdiction. These rights were first recognised by Count Amédée IV of Savoy in a deed dated 19 December 1242[13] and were confirmed to Ebal I the Great, one of the most notable ancestors of the Challant family, when he retroceded the Viscounty of Aosta to the House of Savoy in 1295 in exchange for the lordship of Montjovet. Therefore, the acquisition of the manganese mine at Praborna (Saint-Marcel) and of the pyrite mine at Valmeriana (Ussel) at the beginning of the 15th century can

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[9] In documents FC 161-1D (1681) and FC 164-44 (1763), for example, the word «borne» is used with the meaning of «excavation» or «cavity».

[10] «*alii heredes dicti domini Ebali et homines eorum, per se vel alios possint et eis licitum sit extrahere et duci facere molas de moleria Sancti Marcelli per terram et districtum dictorum Vullielmeti, Ybleti et Aymoneti ad eorum liberam voluntatem*» (FC 10-5); see also FC 319-1, pp. 16-17; FC 320-1, p. 6.

[11] P. Castello, *Le cave di pietre da macina in cloritoscisto granatifero di Saint-Marcel (Valle d'Aosta – Italia)*, in «Revue valdôtaine d'Histoire naturelle», vol. 72, 2018, pp. 17-44.

[12] E. Dulio, *Le miniere degli Challant in Valle d'Aosta*, in «R. Università di Torino, Memorie dell'Istituto Giuridico», Serie II, Memoria V, 1929, 62 pp. [manganese mine of Praborna: pp. 19-20].

[13] AST SC, Cité et Duché d'Aoste, Mazzo 1, fasc. 11 (parchment in Latin).

Figure 1.3. Castle and church of Saint-Marcel (Aosta Valley).
Praborna is located six kilometres upstream in the valley visible in the background.

Figure 1.4. Jacques de Challant, second Count of Challant, one of the owners of the Praborna manganese mine (1440).

«Sir Jacques de Challant, Count of Challant, Lord of Chatillon, Aymaville, Ussel and Verrès, Chamberlain to Duke Louis, cuirassier and governor of Vercelli, 1440». The Challants' coat of arms, in the upper right corner («d'argent au chef de gueules, avec une cotice de sable brochant sur le tout»), is adorned with the collar of the Supreme Order of the Most Holy Annunciation, the chivalric order of the House of Savoy.

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be viewed as a form of pre-emption. This right was extended to many other mines in the region over the centuries, eventually interfering with the mining laws that the House of Savoy attempted to establish in its states[14].

In the 15th century, the lordship of Saint-Marcel, and thus the ownership of Praborna, passed to Pierre (Pietro). However, a series of tragedies befell Pierre's sons. While Claude and Anthoine had no children, François was stripped of his rights for having ordered the assassination of his brother Nicolas, whose two sons also died young[15]. After many vicissitudes, ownership of Praborna passed to another branch of the family, the lords of Aymavilles[16]. In 1458, it belonged to Iaques [Jacques] (Giacomo) de Challant, Lord of Aymavilles and second Count of Challant (Fig. 1.4). This is evidenced by a provision in his will, dated 5 August 1458, which states that «Bonne [de Challant], the testator's wife, during her widowhood, will have the manganese mine located at Saint-Marcel with its revenues»[17], which suggests that these revenues were not negligible. Jacques de Challant died on 15 June 1459 after enjoying a brilliant diplomatic career in the service of the House of Savoy.

His son Louis (Luigi), born on 1 August 1454, was named after the Dauphin Louis, son-in-law of the Duke of Savoy and future Louis XI of France, who

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[14] E. Dulio, *Le miniere degli Challant in Valle d'Aosta*, cit.; A. Garino Canina, *Notizie storiche sulle miniere della Valle d'Aosta*, in «Relazioni e comunicazioni presentate al XXXI Congr. Storico Subalpino di Aosta (settembre 1956)», Aosta 1956, pp. 781-809; G. Pipino, *Spirito Nicolis di Robilant e l'istituzione della prima accademia mineraria in Europa*, in «Physis», vol. XXXVI [n.s., I], 1999, pp. 177-213.

[15] L. Vaccarone, *I Challant e loro questioni per la successione ai feudi dal XII° al XIX° secolo*, cit.

[16] François, the first Count of Challant, died without leaving a son in December 1442. He made a will in favour of his daughters, Catherine and Marguerite. Because this was contrary to Aosta customary law, the agnates of the other branches of the family contested the inheritance. Thanks to an act by Duke Louis of Savoy dated 30 June 1456, Jacques, Lord of Aymavilles, was granted a large part of the estate and the title of Count of Challant, despite the fact that other agnates had priority in the order of succession. In 1456 and 1457, François's daughters and the agnates Boniface and Amédée finally ceded their rights to Jacques (J.-B. de Tillier, *Historique de la Vallée d'Aoste*, cit.; J.-B. de Tillier, *Nobiliaire du Duché d'Aoste*, cit., pp. 96-97, 102-104; L. Vaccarone, *I Challant e loro questioni per la successione ai feudi dal XII° al XIX° secolo*, cit.; P. Durandard, *Histoire généalogique de la Maison de Challant*, cit.).

[17] «*La Bona, moglie del Donante, mentre starà Vedova debba aver la miniera del Maganese sita in San Marcello con gl'emolumenti d'essa*». We have not found the original document, but this text is reproduced on page 14 of a booklet printed in Turin in 1736 and entitled *Sommario nella causa del Sig. Barone Giuseppe Felice Chiallant di Castiglione […] contro il Signor Conte Carlo Giuseppe Bianco di San Secondo* (FC 320-1). This Jacques de Challant could not have been the one who purchased Praborna in 1411, as he was born around 1414.

reportedly carried him to the baptismal font. Louis became the third Count of Challant and inherited the lordship of Saint-Marcel on 10 May 1463, probably receiving the Praborna mine in this capacity, after the death of the dowager Countess Bonne. Following Louis's death in 1487, his widow, Marguerite de La Chambre and his cousin Georges de Challant, who was a prothonotary apostolic, became the guardians of Louis's children. The account book of the lordships of Ussel and Saint-Marcel for the following 1488-1489 financial year contains an enigmatic reference to the manganese mine, indicating that its income was not considered in the accounts: «*de maganesio nihil computat quia prefeta domina recepit*»[18].

Louis's son, Jacques (Giacomo) de Challant, was invested as Lord of Saint-Marcel on 27 October 1490. In 1508, he owned Praborna, as evidenced by a notarial deed «made by Magnificent Lord Jaques de Challant and Noble Anthoine de Salatico, about the manganel of Saint-Marcel, registered by Pierre de Villard on 19 July 1508»[19]. From this period, the account book of the lordships of Ussel and Saint-Marcel for the financial year 1505-1506 has been preserved. It was kept in Latin by the aforementioned Pierre de Villard, and contains an interesting reference to the manganese income: «He [Villard] paid 39.5 *soldi* to Louis du Piellyer of Seysogne for the price due for the 25 *milliara* of manganese he delivered and collected for him»[20]. Although it is impossible to quantify the precise value of 25 *milliara*, it would correspond to around 9615 kg (see Notes), suggesting an annual production of approximately 10 metric tonnes. The surname Piellyer phonetically resembles Palliet, the name of the family that had sold the mine to Jacques de Challant a century earlier. This similarity suggests that the Palliet family continued to operate the mine on behalf of the Challants even after selling it to them. This supports the previous suggestion that the sale was forced due to feudal law.

As the fate of the Praborna mine followed that of the lordship of Saint-Marcel, the next owner was Philibert (Filiberto), the brother of Jacques and the fourth Count of Challant. After him came his son, René (Renato), the fifth Count of Challant, who received the lordships of Aymavilles, Châtillon, Us-

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[18] FC 172-3.

[19] The original document has apparently been lost but it is referenced in the volume 55 of the Challant archives (FC 55, ff. 145r and 145v) and it was transcribed by J. Boson, *Inventaire des archives des châteaux de Challant*, cit., p. 120, n° 904.

[20] «*libravit Ludovico du Piellyer de Seiisognia pro precio facto sibi tradito et levando XXV milliara manganelli 39 sol et 2 quart*», in «*Computa del castellano Pierre du Villar di Ussel e St Marcel p. librate 1505-1506*» (FC 172-8). Seissogne is the first village downstream from the Praborna mine.

sel and Saint-Marcel in 1532. On 14 December 1550, René gave one of his five wives, Mencia of Portugal – whom he had married in January 1528 –, an exquisite but strange gift: 32 *milliers* (ca. 12 tonnes) of manganese from the Saint-Marcel mines[21]. In 1556, he mortgaged the lordship of Saint-Marcel, along with the mine, to pay part of his ransom to Charles de Cossé-Brissac, Marshal of France, who had taken him prisoner in Vercelli, Piedmont, in 1554[22].

In 1557, René arranged the marriage of his eldest daughter, Philiberte (Filiberta), to Federico Madruzzo in an attempt to restore the family's finances. However, Philiberte fled the family castle with a servant she was in love with, taking away jewels and other valuables. That same year, Federico Madruzzo married Philiberte's younger sister, Isabelle (Isabella). René, who died in 1565, disinherited Philiberte because of her «misconduct» and made a will in favour of Isabelle[23], who succeeded in obtaining the title of Countess of Challant in January 1588. Philiberte de Challant tried to sue her sister Isabelle, as did the agnates of the elder branch, the brothers François (Francesco), Georges (Giorgio), Claude (Claudio) and Jehan (Giovanni), who reached a compromise on 18 July 1568, obtaining the lordships of Saint-Marcel and Châtillon. However, Countess Isabelle challenged the arrangement until it was approved by the Senate of Piedmont on 10 July 1573, after which Jehan administered Saint-Marcel, but only for a short time as he died in 1577. Nonetheless, the descendants re-initiated the case against Isabelle's descendants in 1659-1660 and again in October 1693, with the result that the County of Challant and the Barony of Aymavilles passed to the Barons of Fénis and Châtillon in 1696[24].

What about Praborna amid all this mess? In the documents relating to the various cases, the protagonists took care to mention the manganese mine, which appears to be an important source of income. Countess Isabelle secured the usufruct of the mine until her death in 1588, even though her cousins were the legal owners[25]. One of them, Georges (Giorgio), finally inherited the mine

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[21] FC 166-1.

[22] J.-B. de Tillier, *Historique de la Vallée d'Aoste*, cit., pp. 196-198.

[23] L. Vaccarone, *I Challant e loro questioni per la successione ai feudi dal XII° al XIX° secolo*, cit. See René's testament in J.-B. de Tillier, *Nobiliaire du Duché d'Aoste*, cit., pp. 110-111.

[24] J.-B. de Tillier, *Historique de la Vallée d'Aoste*, cit.; J.-B. de Tillier, *Nobiliaire du Duché d'Aoste*, cit.

[25] E. Dulio, *Le miniere degli Challant in Valle d'Aosta*, cit., p. 17; FC 162-7; FC 320-1, p. 16 (on 10 July 1568): «*e riservato a detta Dama durante sua vita I'usufrutto della montagna sita nel territorio di San Marcello, ove si escava, e raccoglie il Manganese…*». On 10 August 1573, Isabelle de Challant sold 100 «migliers» of manganese from Saint-Marcel (FC 261-10).

on 5 February 1591, together with the lordship of Saint-Marcel[26]. However, Georges died on 5 February 1595, leaving significant debts behind. His widow, Adrienne (Adriana) Costa, acting as guardian of her children, first leased the mine for five years on 10 September 1596 to Carlo Perrone, who was to extract 30 *milliers* of manganese – approximately 11.5 metric tonnes – each year at a price of 400 *écus*[27]. The lease was renewed on 13 April 1600 for an annual rent of 800 *écus*[28]. Finally, on 24 October 1604, Adrienne de Challant, in order to repay a debt of 1800 *scudi* and 7 *fiorini* contracted by her late husband and acting as guardian for her children, sold the manganese mine to Carlo Perrone[29], who lived in the city of Ivrea and was awarded the title of Count of San Martino in the same year[30]. Importantly, Adrienne de Challant managed to include a redemption clause in favour of her family in the contract, which would enable them to buy back the mine if they could reimburse the buyer or his heirs for the capital and interests – a staggering 8% per year!

A few years later, in 1612, the validity of the contract was challenged by her son Paul-Emmanuel (Paolo Emanuele), once he had reached adulthood. The case was heard in the Senate of Turin, where Paul-Emmanuel argued that the sale of the mine by his mother was illegal because the mine was an inalienable feudal asset. He obtained an initial favourable ruling on 26 June 1612[31]. The

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[26] Following the death of Jehan (Giovanni), Saint-Marcel and the manganese mine reverted to his brother Claude (Claudio) on 8 August 1577 (FC 320-1, p. 17). Following Claude's and his son Anthoine's deaths, it was another brother, Georges (Giorgio), who inherited it on 5 February 1591 (FC 320-1, p. 18), and made an agreement with his last brother François (Francesco) on 15 June 1591 to take ownership of the latter's half of the manganese mine (copy in FC 162-3).

[27] FC 161-1A.

[28] FC 161-2B.

[29] AST SR, Perrone di San Martino, partizione 1, cartella 4, fascicolo 58 (original in Italian); FC 161-2A, FC 161-3, FC 165-3 (copies).

[30] P. Dagna, *Un diplomatico ed economista del settecento: Carlo Baldassarre Perrone di San Martino (1718-1802)*, in «Figure e gruppi della classe dirigente piemontese nel Risorgimento», Istituto per la storia del Risorgimento, Torino 1968, pp. 9-46.

[31] AST SR, Perrone di San Martino, partizione 1, cartella 4, fascicolo 59: «*Sumario nella causa del Molto Ill[ustre] Sig. Carlo Perrone San Martino contra l'Illustriss[imo] Sig. Paulo Emanuel Chialant, Sig. di Castiglione*»; *idem*, fascicolo 57: «*Copia di cedola del signor barone di Castiglione relativa alla vendita della miniera a favore di Carlo Perrone*»; FC 165-8, FC 161-2B, FC 161-3: «*Atti seguiti avanti il Senato nella causa del predetto signor auditore Perrone contro detto signor Paolo Emanuele di Challant, barone di Castiglione, ad effetto d'esser mantenuto nel possesso ed uso d'essa miniera […]. E per sentenza deli 26 giugno 1612 è stato detto signor barone di Castiglione mantenuto nel possesso della suddetta cava del*

dispute was temporarily resolved on 22 March 1614 by an arbitration award[32], which ruled that the mine should be returned to Paul-Emmanuel de Challant, on the condition that he repaid all his debts to the opposing party within six months; otherwise, the mine would revert to the Perrone family, who would hold it until the debts were repaid. This eventually happened because the Challants failed to fulfil their obligations within the six-month period.

Despite these legal troubles, Paul-Emmanuel de Challant behaved as if he were the legitimate owner of the mine. In December 1611, he promised to supply Agostino Gromo, of Biella, and Giovanni and Giuseppe Desio, of Milan, with 80 *migliara* of manganese every year for seven years[33]. As Paul-Emmanuel failed to deliver the promised manganese ore, Gromo and the Desios appealed to Duke Charles Emmanuel I[34] and obtained permission to extract the ore directly from the Praborna mine themselves[35]. Paul-Emmanuel de Challant also ordered Michel Freidoz to deliver 40 rups of manganese ore to Antoine Venez in 1615[36], and in 1618 he granted Giuseppe Desio 1000 rups of it[37]. Indeed, deliveries of ore under the names of Agostino Gromo and then Michel Freidoz are recorded in the registers of the secretariat of the Châtillon barony for the years 1612 to 1620[38]. In 1619, Paul-Emmanuel Challant went so far as to mortgage the mine to finance his sister Bona's dowry[39].

Meanwhile, Carlo Perrone attempted to stand up to Paul-Emmanuel's abusive exploitation of the mine. In 1611 and 1612, he succeeded in having the

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manganese». Also see the plea in favour of Paul-Emmanuel de Challant (handwritten notes: FC 165-30; text printed in Latin and Italian: FC 165-28).

32 FC 161-7: «*Sentenza arbitramentale proferta […] sulle differenze insorte tra il signor Paolo Emanuel de Challant, barone di Castiglione, […] ed il signor Carlo Perrone, d'Ivrea, […] circa il possesso che doveva continuare ad avere il detto signor barone della miniera del manganese, nonostante la vendita fatta al detto signor Perrone dalla dama [Adriana] di Castiglione*»; AST SR, Perrone di San Martino, partizione 1, cartella 4, fascicolo 60. Also see the draft transaction between Paul-Emmanuel de Challant and Carlo Perrone concerning the manganese mine (FC 165-29), and E. Dulio, *Le miniere degli Challant in Valle d'Aosta*, cit.

33 FC 161-1B; FC 161-4B.

34 23 December 1612: FC 165-6.

35 17 June 1612: FC 343-18, FC 161-4B.

36 FC 165-10.

37 FC 165-16.

38 FC 165-9, FC 165-11, FC 165-12, FC 165-15, FC 165-17; see also FC 165-14.

39 FC 301-1, p. 22; FC 319-1, pp. 21, 32; FC 320-1, p. 22.

ore passing through the town of Ivrea seized by the city authorities[40]. In 1618, he reached an agreement with Giovanni and Giuseppe Desio, alongside the heirs of Agostino Gromo. In exchange for a permit to extract 700 *migliara* of manganese ore, they recognised Carlo Perrone's rights to the mine[41]. Finally, on 9 November 1621, the Duke of Savoy, Charles-Emmanuel I, intervened at the request of Count Carlo Perrone, forcing Baron Paul-Emmanuel de Challant to stop obstructing the exploitation of the mine[42].

However, the Challants had not yet said their last word. The dispute arose again in 1632[43], 1636[44], 1640[45], 1664[46] and 1670[47], when the Challants tried to regain possession of the Praborna mine. They appealed to the dukes Victor-Amédée I and Charles-Emmanuel II of Savoy[48] and claimed that their opponents had already been repaid for their debts thanks to the mine's income[49]. The transaction of 15 June 1671[50] definitively put an end to all disputes by

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[40] FC 161-5; FC 165-4.

[41] FC 161-4A; 700 *migliara* is equivalent to approximately 270 metric tonnes (see Notes).

[42] FC 165-19. Also see the draft letter from Paul-Emmanuel de Challant to the Duke of Savoy (FC 165-31).

[43] Case of Baron Perrone against Baron de Châtillon presented to the Ducal Chamber regarding the manganese issue (FC 161-4C); also see: FC 166-2, FC 166-3.

[44] On 8 March 1636, Baron Perrone appeals to the Duke of Savoy to order Baron de Châtillon to stop preventing him from excavating and exporting manganese from Saint-Marcel (FC 165-21).

[45] On 29 February 1640, at the request of Paul-Emmanuel de Challant, Duke Charles-Emmanuel prohibited Baron Perrone from transporting or exploiting the manganese ore, under penalty of a fine of one hundred gold *scudi* (FC 166-4, FC 161-11; see also FC 165-22 dated 8 March 1640). On 11 March 1640, the previous decision was cancelled following an appeal by Baron Perrone to the Duke (FC 161-12). Following Paul Emmanuel's death on 17 September 1641, his widow, Baroness Leanza, tried to lease the mine to Alessandro Salvay for the extraction of 7500 rups of ore over a period of ten years (FC 161-13).

[46] On 1 March 1664, Countess Prospera Perrone submitted a petition to the *Camera dei Conti*, requesting that François-Jérôme de Challant be prohibited from extracting manganese from Saint-Marcel in future (FC 161-15).

[47] FC162-5; file FC 162-3 also contains numerous documents from the trial of the case held in 1670.

[48] FC 166-2; FC 166-3; FC 166-4; FC 161-11; FC 165-21.

[49] Documents FC 162-4 and FC 165-23, dated 10 and 12 March 1670, detail the mine's income from 1614 to 1670, and calculates the remaining capital and interest (at an annual rate of 8%) owed by Baron de Châtillon to the heirs of Antonio Perrone.

[50] «*Transazione seguita tra il signor Francesco Gerolamo di Challant, barone di Castiglione […] da una parte, e la signora contessa Prospera Perrone S. Martino di Bellagarde […] in se-*

transferring the highly contested mine to François-Hierosme [Jérôme] (Francesco Gerolamo) de Challant, son of the late Paul-Emmanuel.

Although they had lost possession of the Praborna mine, the Perrone di San Martino family seized the opportunity to continue trading manganese. In 1693, an amicable settlement was negotiated to resolve a triangular dispute involving the Challant, Perrone and Falletti families. The agreement included the sale of 17000 *rubbi* – approximately 163 metric tonnes – of manganese by François-Jérôme de Challant, Baron of Châtillon, to Carlo Filippo Perrone di San Martino at a price of 12 *soldi* per *rubbo*, totalling 10200 *lire*. Seven thousand *rubbi* were already available in Saint-Marcel and a further 10000 were to be extracted from the Praborna mine[51].

In the early 18th century, ownership of the mine passed to two of François-Jérôme's sons: Joseph-Félix (Giuseppe Felice), Baron of Châtillon and Aymavilles, and Georges-François (Giorgio Francesco), Count of Challant, who managed the mine together and signed the contracts *in solidum*. Georges-François deserves to be remembered for his knowledge of chemistry. In 1727, he discovered a phosphorus-based substance that ignited when rubbed, thus anticipating the invention of matches by almost a century[52]. However, it does not seem that he studied the Praborna minerals. After him, the mine passed to his son, Charles-François-Octave (Carlo Francesco Ottavio).

In one of his reports on the Aosta Valley in 1756[53], the Inspector General of the kingdom mines, Spirito Benedetto Nicolis de Robilant, erroneously asserts that Baron Perrone had discovered the Praborna manganese mine at the beginning of the 18th century and leased it at a moderate price from the Count of Challant. He also blames the Count for flooding the European markets with manganese ore, thereby devaluing the mine. Nicolis de Robilant may have been misled by his gratitude towards Carlo Baldassarre Perrone di San Mar-

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guito alle differenze e lite tra essi vertita per riguardo alla montagna e miniere del manganese stata nel 1604 data in paga dalla dama Adriana Costa di Challant» (FC 162-6).

[51] «*Transazione seguita tra il sig. barone Francesco Gerolamo Challant di Castiglione ed il sig. barone Carlo Filippo Perrone S. Martino per riguardo alla miniera nella quale si estrae il manganese ed anche circa la dote della signora contessa Faletti*» (12 August 1693; FC 49-1).

[52] L. Alvazzi-Del Frate, *La famiglia di Challant. Brevi cenni storici raccolti nel nono centenario dell'insediamento della Dinastia Sabauda in Val d'Aosta*, in «Bollettino storico-bibliografico subalpino», vol. XXXIV, 1932, pp. 249-262 + 5 tab.

[53] On 10 December 1756, «*Esposizione concernente le miniere ed indizi della Valle d'Aosta, alla quale si uniscono diversi reflessi circa il modo di promuovere la coltura*.» (AST SR, Ufficio generale delle finanze, Seconda Archiviazione, Miniere, Capo 20, Mazzo 7).

tino (1718-1802), a prominent diplomat of the Perrone family who had obtained a scholarship for him to study mining sciences in Germany, particularly in Freiberg, Saxony[54].

Since the reign of Duke Charles II in the early sixteenth century, the House of Savoy had tried to impose the right of the sovereign over that of the feudal lords, with regard to the mines[55]. In the mid-18th century, the Savoy states reinforced this policy and opposed the privileges that the Challant family had enjoyed for centuries over the mines under their jurisdiction. In 1752, the Inspector General of the mines, Nicolis de Robilant, obliged Count Charles-François-Octave de Challant to sign a convention that confiscated the gold, copper and silver mines located on the north bank of the Dora Baltea, the exploitation of which had long been neglected[56]. A similar convention was imposed on François-Maurice-Grégoire (Francesco Maurizio Gregorio) de Challant in 1775 regarding the Arbaz gold mine in the Challant Valley[57].

As for the Praborna mine, history repeated itself in the same way as a century and a half earlier, when it was sold to Carlo Perrone. Still penniless, the Challant family first rented the manganese mine for six years, on 8 February 1747[58], and then again for a further four years, on 5 April 1752[59], to a lawyer from Aoste, Jean-Baptiste Davise, who was already the concessionaire of the iron mines of Ussel and the Pontey foundries. Two years later, on 26 January

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[54] P. Dagna, *Un diplomatico ed economista del settecento*, cit.; G. Pipino, *Spirito Nicolis di Robilant e l'istituzione della prima accademia mineraria in Europa*, in «Physis», vol. XXXVI (n.s., vol. I), 1999, pp. 177-213.

[55] E. Dulio, *Le miniere degli Challant in Valle d'Aosta*, cit.

[56] AST SC, Materie economiche, Seconda addizione, Miniere, Mazzo 1, Fascicolo 6; on 16 July 1752: «*Convenzione fatta col Conte di Challant per la cessione a favore delle Finanze delle miniere ad esso Conte spettanti nel Ducato d'Aosta*»; published by E. Dulio, *Le miniere degli Challant in Valle d'Aosta*, cit., pp. 54-57.

[57] AST SC, Ufficio generale delle finanze, Seconda Archiviazione, Miniere, Capo 20, Mazzo 93; on 19 and 21 August 1779: «*Convention entre le Seigneur Comte Maurice de Challant, et le Royal Patrimoine portant cession en faveur des Royales finances du droit d'exploiter le filon d'or appellé le fillon de Bouchej situé dans la montagne de Arbaz dans la vallée de Challant*»; published by E. Dulio, *Le miniere degli Challant in Valle d'Aosta*, cit., pp. 57-62.

[58] On 8 February 1747, Davise signed a contract to extract 6000 rups of manganese ore (ca. 58 metric tonnes) at Saint-Marcel over a period of six years, some of which he sent to Paris via Lyon (see letters of 21 December 1737, 11 and 22 September 1747: FC 165-50; draft agreement: FC 236-48).

[59] FC 161-01V, on 5 April 1752: «*Le comte Charles-François Octave de Challant et l'avocat Jean-Baptiste d'Avise établissent une convention pour l'exploitation des mines de manganèse de St.-Marcel pour l'espace de quatre ans*».

1754, Count Charles-François-Octave de Challant sold the manganese mine to Davise for 4000 *livres*. The contract included a repurchase clause, but the count was never able to exercise it[60]. On 25 October 1756, Davise paid him an additional sum of 750 *livres* on top of the original 4000[61].

Once again, the Challants behaved as if they were still the owners of the mine. In 1763, the Count of Challant signed a contract with Jean-Vincent Ferraz for the extraction of 1000 rups of manganese[62]. In 1775, his heir, François-Maurice-Grégoire de Challant, took legal action against the widow Davise and her sons, Joseph and Victor, as did Paul-Emmanuel de Challant against the Perrones in 1612. However, this time, the Count of Challant could hardly argue that the Praborna mine was an inalienable asset of the Saint-Marcel fiefdom – although he did attempt to do so – because the Challants, being perpetually short of money, had sold the lordship of Saint-Marcel to the intendant Carlo Bianco, Count of San Secondo, on 12 March 1665[63]. The ensuing lawsuit lasted until December 1779, but the Davises remained the owners of the mine[64]. Due to the lack of archives, little is known about the Davises' exploitation of the mine. When the renowned geologist Horace-Bénédict de Saussure visited it on 20 August 1792, the mine was still owned by «Mr d'Avise», who had provisions kindly brought to de Saussure on the banks of the stream in the Praborna pastures[65].

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[60] FC 162-8, on 26 January 1754 (original); FC 162-9 (copy); published by E. Dulio, *Le miniere degli Challant in Valle d'Aosta*, cit., pp. 47-50: «*Le comte Charles-François-Octave de Challant vend sous clause de rachat à Jean-Baptiste Davise, trésorier du Duché, toutes les minières de manganèse découvertes et à découvrir dans la paroisse de St-Marcel pour le prix de 4000 livres.*». Because of an ongoing contract with Mr. Parracha of Turin for the extraction of 4000 rups of manganese, compensation is being considered.

[61] «*Contract de adjonction de prix per spectable avocat Jean Baptiste Davise en faveur du très-illustre seigneur comte Charle François de Challant le 25 8bre 1756.*» (FC 162-9; copy).

[62] FC 164-44.

[63] FC 320-1; FC 162-5, ff. 153r-158r (copy). The Count of Challant and the Count of San Secondo, Lord of Saint-Marcel, clashed over the exploitation of mines in the territory of Saint-Marcel, taking the dispute as far as a trial – once again – before the Senate of Piedmont in 1773 (FC 162-7; FC 319-1; FC 319-2). The dispute focused on the extraction of ore around a pillar, which reportedly endangered the safety of the mine. However, examination of the texts (FC 162-7; FC 166-53) reveals that it was a copper mine, rather than a manganese mine contrary to what was reported by J.-C. Perrin, *Inventaire des Archives des Challant*, cit., t. II, p. 266 (n° 53). The mine was therefore most likely the Servette mine, located near Praborna.

[64] FC 162-9; FC 338-15.

[65] H.-B. de Saussure, *Voyages dans les Alpes, précédés d'un Essai sur l'histoire naturelle des environs de Genève*, S. Fauche, Neuchâtel 1779-1796, 4 vol. in-4 [vol. 4, pp. 456-458].

What was the mine like? A visit report by Pietro Francesco Ferrari, dated 6 September 1723, provides only vague information[66]: Ferrari penetrated a first cavity, which did not appear to be very deep. Other cavities had not changed since his last visit. According to the miner Battista Anserme, the first of these had reached the limits of mineralisation. In his *Voyages dans les Alpes*, de Saussure[67] provides a more precise account, noting on 20 August 1792 that «the exploited part, which can be considered [...] as a lens parallel to the layers of the mountain, is 15 or 20 feet [5 to 7 m] thick on the outside and becomes thinner as it penetrates the mountain [...]. Its depth, from the entrance to the bottom, is about 50 feet [15 m]. It dips westward by fifteen to twenty degrees at the top and by a little less at the bottom». This description corresponds well to the main cavity, which is still visible today but was then less deep.

1.2 The Praborna mine, during the 19th and 20th centuries

The French Revolution and the subsequent Napoleonic conquests caused disruption to mining legislation[68] and ownership. The Challant dynasty came to an end, as did the lordship of Saint-Marcel and the Most Serene Republic of Venice – the main customer for manganese ore. This marked the beginning of a new era for the Praborna mine.

In 1805, almost three years after the Aosta Valley was incorporated into the French *département de la Doire*, Laurent Bordon, a tavern keeper from Nus, acquired the Praborna mine and the neighbouring pastures through notarial deeds dated 1 and 3 Fructidor, year XIII of the French Republic (19 and 21 August 1805). He purchased them from Joseph Droz and Jean Barthélemy of the Enchasaz hamlet in Saint-Marcel, for 50 and 70 francs respectively[69]. Bordon took over the exploitation of the manganese mine, which produced 10 to 15 metric tonnes of ore per year and employed up to five miners from 1807 to 1809[70]. Selling the ore at 0.100 or 0.115 francs per kilogram provided him with a comfortable annual income of around 1000 francs.

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[66] FC 165-38. Unfortunately, we could not find the visit report and «the topographic map made at the manganese vein» by Master Albertaglio in September 1749 (FC 165-170).

[67] H.-B. de Saussure, *Voyages dans les Alpes*, cit.

[68] A. Zanolini, *Sopra due discorsi intitolati della Legislazione Mineraria e delle scuole delle Miniere [...]. Considerazioni di Antonio Zanolini*, Tip. Eredi Botta, Torino 1861, 174 pp.

[69] FD 11 J 738.

[70] ANF F/14/1036, pièces 9-12, 233.

However, Laurent Bordon paid little attention to the claims of the Davise family, who had operated the mine during the last decades of the *Ancien Régime*. In 1804, Réan, the lawyer representing the Davises, asked Countess Gabrielle Canalis de Cumiana, the widow of François-Maurice-Grégoire de Challant, for copies of documents relating to the sale of Praborna to the Davise family, whose right «to exploit the manganese mine near St Marcel […] has recently been disturbed by a man named Bourdon [*sic*] who supposedly had permission from the government to exploit it»[71]. Interestingly, Réan's letter, dated 7 April 1804, was written before Bordon purchased the mine in August 1805, which suggests that Bordon may have operated the mine before he owned it. The Countess responded evasively, stating that the disruption to the Challant archives during the revolutionary unrest had prevented her from locating the requested documents[72].

To comply with French mining legislation, Laurent Bordon was required to obtain a concession and pay an annual fee, as stipulated in a decree issued on 8 June 1811 by the prefect of the department, Auguste Jubé de La Perelle. On 5 July 1811, Bordon therefore submitted a concession application to the Ivrea prefecture[73], proposing a modest annual fee of 20 francs, given that «the outlets for manganese are extremely limited» during wartime. Madame Davise de Charvensod, of Aosta, immediately contested Bordon's application by sending a letter to the *Conseil général des mines* in Paris[74]. She claimed that her three young daughters had inherited the right to exploit the mine, which had been purchased by Jean-Baptiste Davise from Charles-François-Octave de Challant in 1754 and 1756. Attached to her letter were the transfer deed and receipt for the price paid by the Jean-Baptiste Davise half a century earlier. The *Conseil des Mines* forwarded the file to the prefect of the Doire department, who was asked to investigate the matter[75]. On 17 July 1812, the prefecture asked Laurent Bordon to provide clearer plans than those presented

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[71] FC 162-10.

[72] Gabrielle Canalis de Cumiana married Aimé-Louis Passerin d'Entrèves as her second husband. Upon her death on 14 August 1841, she bequeathed all the properties she had inherited from the Challant family to him. These included the archives, which were deposited in the Regional Historical Archives of the Autonomous Region of the Aosta Valley in Aosta in 1970 (J.-C. Perrin, *Inventaire des Archives des Challant*, cit.).

[73] FD 11 J 738; AST SR, Ministero delle finanze, Intendenza di Ivrea, Categoria VI. Miniere, Mazzo 865 + drawing n° 78.

[74] ANF F/14/1036 pièces 236. See above for Davise's purchase of the mine.

[75] ANF F/14/1036 pièces 234, 235.

on 5 July 1811 (see Fig. 1.5) if he wished to obtain the concession[76]. It does not appear that Bordon responded.

In support of his application, Bordon submitted a watercolour picture depicting the site (Fig. 1.5), which shows seven cavities from which the ore was extracted. These cavities are more or less horizontally aligned (5 in Fig. 1.5), with the largest extending eight metres into the mountain and reaching a height of eight metres. In an 1807 report, mine engineer Jean-François D'Aubuisson provided a slightly different description[77]: «A layer 5-6 metres thick, inclined at 10°, not very extensive; an open-air pit and a gallery; length 28 metres, width 12 metres, height 6 metres; three miners». Jean-Laurent Martinet, the subprefect of Aosta, also provided an interesting description of the mine[78]: «A manganese mine was exploited for a long time in the municipality of Saint-Marcel. Difficulties regarding the ownership of the mine soil caused the suspension of the mining activities, which will resume as soon as the legal issues are resolved. This mine contains a curious mixture of diverse substances. The grainy manganese oxide is mixed with various other substances, including: (a) a white, fibrous or acicular substance that seems to be actinolite and asbestos; (b) a laminar white carbonated lime; (c) a red-brown substance that appears to be epidote [i.e., piemontite]; (d) this red-brown substance within regular quartz; (e) and finally, all of these white, grey and red substances together».

Following Napoleon I's abdication in April 1814, the *département de la Doire* was returned to the House of Savoy, who restored the Kingdom of Piedmont-Sardinia. Laurent Bordon and then his sons, Joseph and Antoine, operated the mine for many years despite not having obtained the concession. A royal note dated 5 June 1826 required them to fulfil the legal requirements following a period of reprieve, but they apparently neglected to do so. The Kingdom's mining engineer reported their abusive exploitation of the mine, and, on 1 April 1854, the Intendancy of Aosta notified them that they had to regularise their situation. On 10 June 1856, they applied for a regular concession, which was finally granted the following year. However, they were required to pay royalties retroactively from 1841 onwards[79].

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[76] AST SR, Ministero delle finanze, Intendenza di Ivrea, Categoria VI. Miniere, Registro 867, p. 14.

[77] «*Statistique minéralogique de la Doire*», 1807 (ANF F/14/1034).

[78] «*Notes statistiques sur l'arrondissement d'Aoste (Doire)*», 4 avril 1807 (ANF F/20/180 pièce 170).

[79] FD 11 J 738, n° 253.

Figure 1.5. The Praborna mine in 1811. Watercolour 40 cm × 30 cm.

Translation from French:

> «Regular plan of the surface of the manganese mine located in the mountain of the commune of Saint-Marcel in the Aosta district, in the Doire department, called La Borma and Praborna, belonging to Mr Laurent Bordon.
>
> 1: Big stream;
> 2: White channel of La Barma;
> 3: Vovery stream flowing to Praborna;
> 4: Path leading to the pastures and excavations;
> 5: The seven excavations where the ore is extracted, the largest of which is dug eight metres into the mountain and as much in height;
> 6: Other pastures belonging to other people;
> 7: Mr Laurent Bordon's pastures at the mine.
>
> Aosta, 20 June 1811: Crosa, surveyor. Seen by the mining engineer at Ivrea on 29 July 1811: F[irmin] Cocquerel».

AST SR, Ministero delle finanze, Intendenza di Ivrea, Categoria VI. Miniere, Mazzo 865, n° 78.

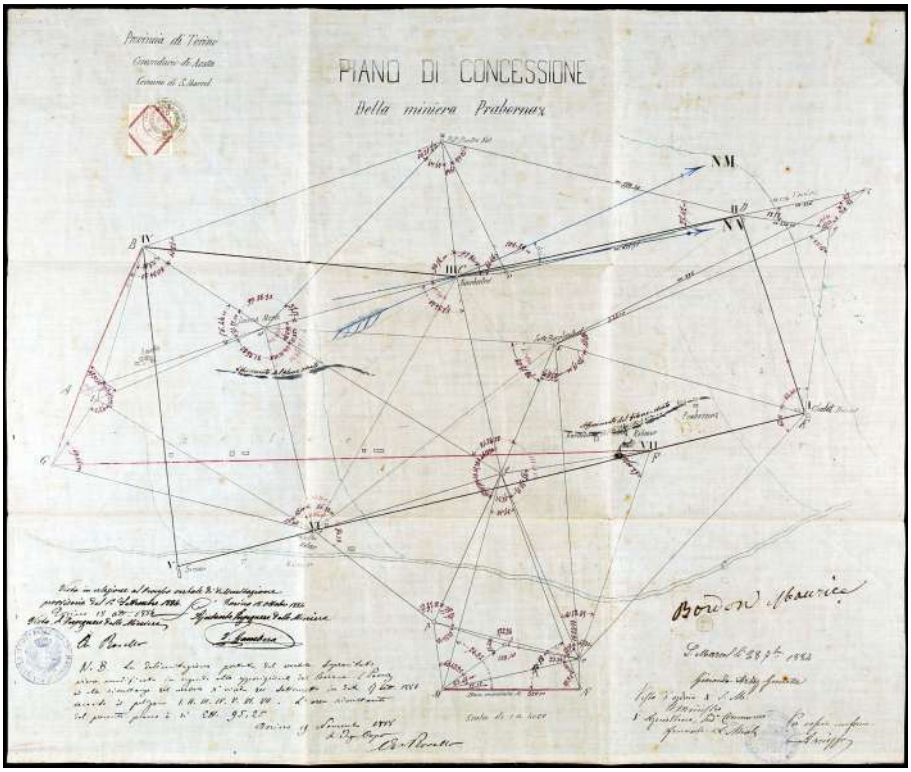

Figure 1.6. The Praborna concession in 1884, modified in 1886.

Translation from Italian:

> «certificate in relation to the provisional delimitation report of 1 September 1884. Turin, 18 October 1884 [signatures of the Mining Engineer and his assistant].
>
> Note: The above-mentioned delimitation has been modified due to Baron L. Peccoz's objections and the results of the undersigned's visit report, dated 10 September 1886, following polygon I-II-III-IV-V-VI-VII. The resulting area is 95.25 hectares. Turin, 19 November 1888 [signature]».
>
> On the right: «Bordon, Maurice. St Marcel, 28 September 1884 [Signature of the surveyor]. Approved by H.M. Ministry of Agriculture, Industry and Commerce [signatures]».

AST SC, Distretto Minerario del Piemonte, Terzo versamento, Piani di miniera, mazzo 15, fascicolo 39.

In 1837, Charles-Marie-Joseph Despine, the general inspector of the kingdom's mines, provided details of the mining operations at Praborna. The average annual production of ore is 9.6 to 11.5 metric tonnes. Work is only carried out for four months of the year, during the summer, and the mine employs three miners, two sorters and a blacksmith, who are paid 1.50, 1.25 and 1.75 *lira sabauda* per day respectively [80]. Average annual production increased from 18.6 tonnes in the 1840s[81] to 88 tonnes in the 1880s, peaking at 150 tonnes in 1884, but it fell below 10 tonnes after 1890[82].

Complications arose on 23 May 1883, when Baron Luigi de Peccoz, the owner of a hunting lodge and land beyond Mulac, south of Praborna, applied for a prospecting permit on his property[83]. A map dated 29 January 1884 suggests that he intended to prospect a manganese-rich level near Rualla, south of Praborna[84]. However, he had to modify the boundaries of the requested prospecting area, because he had inadvertently included part of the Praborna concession within it. In an attempt to thwart the baron's plans, Jacquemet and the Bordon brothers – the owners of the Praborna mine – sent a request to the subprefecture of Aosta on 25 May 1884, asking for their concession to be extended to cover the entire area. The baron interjected an appeal, prompting the Ministry of Public Works and the Prefecture of Turin to intervene. If this trivial dispute took on the scale of a matter of state, it was because Baron Peccoz was well-connected, eventually becoming a very close friend of the Queen of Italy, Margherita of Savoy – her lover, some say. An arbitration took place on site on 10 September 1886, and the southern boundary of the concession was revised in an attempt to satisfy both parties[85] (Fig. 1.6). Did Baron Peccoz

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[80] FD 11 J 733.

[81] FD 11 J 714. Another document (FD 11 J 738, n° 153, p. 2) indicates that production between 1841 and 1855 totalled 284 metric tonnes (i.e., an average of 18.9 tonnes per year), of which 66.5 tonnes were stored and 217.5 tonnes were sold at the mine for 70 *lire* per tonne. Some of the original values were expressed in rups, but for convenience, we converted them into metric tonnes, on the basis of 1 rup equalling 9.615 kg (see Notes). B. Gianotti indicates that the annual production in 1845 was 23 tonnes, 6.45 of which were destined for Venice (in *Le Alpi che cingono l'italia*, Torino 1845, p. 137).

[82] Yearly statistics are provided in *Relazione sul servizio minerario nel ... [year]* from 1877 to 1882; and in *Rivista del Servizio minerario nel ... [year]*, from 1883 to 1915.

[83] AST SC, Distretto Minerario del Piemonte, Primo versamento, Piemonte, Miniere, Permessi e concessioni, Provincia di Torino, mazzo 74, fascicolo 1141.

[84] *Idem*: *Plan démonstratif de la montagne de Rualla territoire de Saint-Marcel, 22 janvier 1884*.

[85] AST SC, Distretto Minerario del Piemonte, Primo versamento, Piemonte, Miniere, Permessi

really intend to open a manganese mine to the south of Praborna? Anyhow, he died while hiking with Queen Margherita in the Monte Rosa massif on 18 August 1894, without having realised his mining ambitions.

These bureaucratic hassles had an unexpected positive effect: the creation in 1886 and 1887 of a concession map[86] (Fig. 1.6) and mine plans[87] (Fig. 1.7), which provide valuable information on mining operations. The concession map, in particular, shows that the manganese-rich level near Rualla that Peccoz coveted was considered the southern extension of the NW-dipping mineralised level of Praborna (Fig. 1.6). The mine plan shows the main cavity (Fig. 1.7; marked in green in Fig. P.4), which was smaller than it is today. It had west-facing digitations that could correspond to the bulges of the ore lens. The map also shows two houses: one for the foremen and one for the miners. The latter was already in ruins by 1903 (Figs. P.4 and 1.9) and has since disappeared under a landslide.

Mining operations became very difficult during the 1890s due to drainage issues at the base of the main cavity (Fig. P.4). Consequently, production fell to 0.5 tonne in 1896. The proposed solution was to dig a gallery at a much lower level in order to pierce the bottom of the main cavity and allow it to drain. The entrance to this gallery, known as *ribasso inferiore*, is already visible on the 1887 plan (Figs. 1.7 and P.4). However, it had not been completed by 1900, when the historic owners sold the mine to Alfred Theys, a Belgian entrepreneur who managed the iron mines of Cogne, in the neighbouring Urtier Valley. Twenty workers were employed at the Praborna site to resume excavation of the drainage gallery. They reached the bottom of the cavity on 10 January 1902, allowing the water to be evacuated[88]. Operations could therefore resume and be modernised. As his project required a larger concession area, Alfred Theys submitted a file to the Turin *distretto minerario* on 14 September 1902. In response to requests from this bureau, he provided

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e concessioni, Provincia di Torino, mazzo 74, fascicolo 1141: *Verbale di visita alla concessione detta Praborna in territorio di St Marcel*; AST SC, Distretto Minerario del Piemonte, Terzo versamento, Piani di miniera, Mazzo 15, fascicolo 39: *piano di concessione della miniera Prabornaz*, 1884.

[86] *Idem*: *piano di concessione della miniera Prabornaz, 1884*.

[87] AST SC, Distretto Minerario del Piemonte, Terzo versamento, Piani di miniera, Mazzo 15, fascicolo 39: *mine de Saint-Marcel, cultivée par les concessionnaires Bordon-Jacquemet, plan des galeries, 28 janvier 1887*.

[88] *Un ancien filon remis en activité*, in «Le Duché d'Aoste», 12 février 1902, p. 3; see also «L'Avenir», 27 février 1902, p. 2; *Réveil industriel*, in «Jacques Bonhomme, journal populaire, politique, administratif, économique de la Vallée d'Aoste», 4 juillet 1902, p. 1.

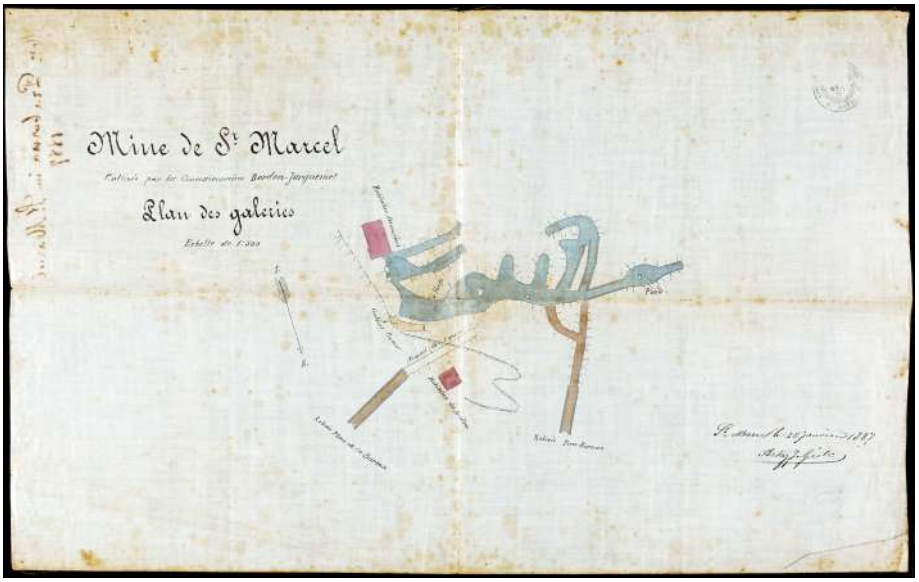

Figure 1.7. The Praborna mine in 1887.

Translation from French:

> «Saint-Marcel mine operated by the concessionaires Bordon-Jacquemet. Gallery plan. Scale 1:500».

From top to bottom:

> «workers' housing; forge; sump; Cavour's cabinet; work of the year (gallery); owners' housing; gallery entrance Plan de la Barma; gallery entrance Praz-Borna; St Marcel, on 28 January 1887 [surveyor signature]».

Note that the north direction is erroneous by about 30°.

AST SC, Distretto Minerario del Piemonte, Terzo versamento, Piani di miniera, mazzo 15, fascicolo 39.

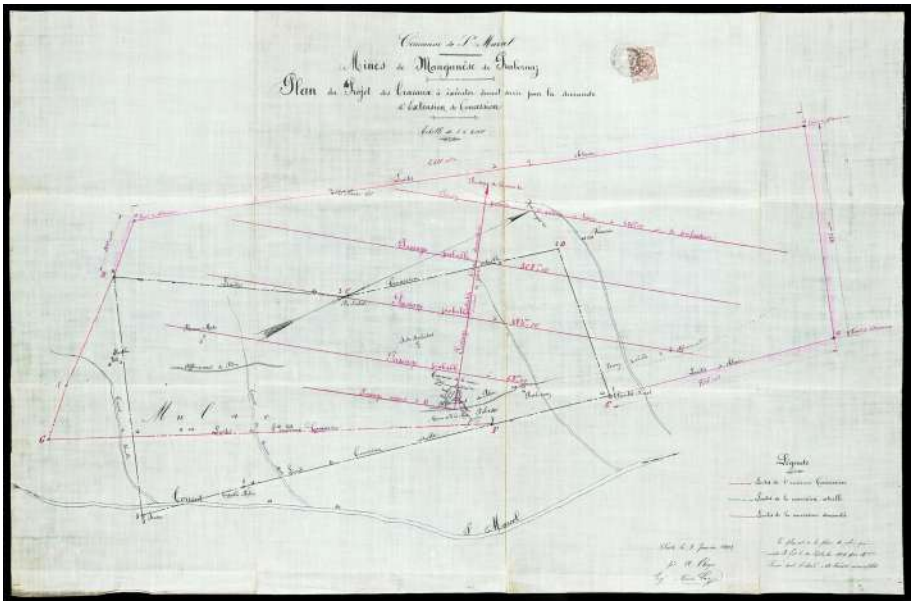

Figure 1.8. Alfred Theys's 1903 project to extend the concession of the Praborna mine.

Polygon A-B-C-D-E-F-G: limits of the previous concession;
black polygon 1-2-3-4-5: limits of the current concession;
red polygon: limits of the demanded concession;
red lines: projected winze inclined at a 30° angle to the NNW, connecting four horizontal galleries (see text). «Aoste le 7 janvier 1903. Pour A. Theys, ing. Marius Lauze».

AST SC, Distretto Minerario del Piemonte, Terzo versamento, Piani di miniera, mazzo 15, fascicolo 39.

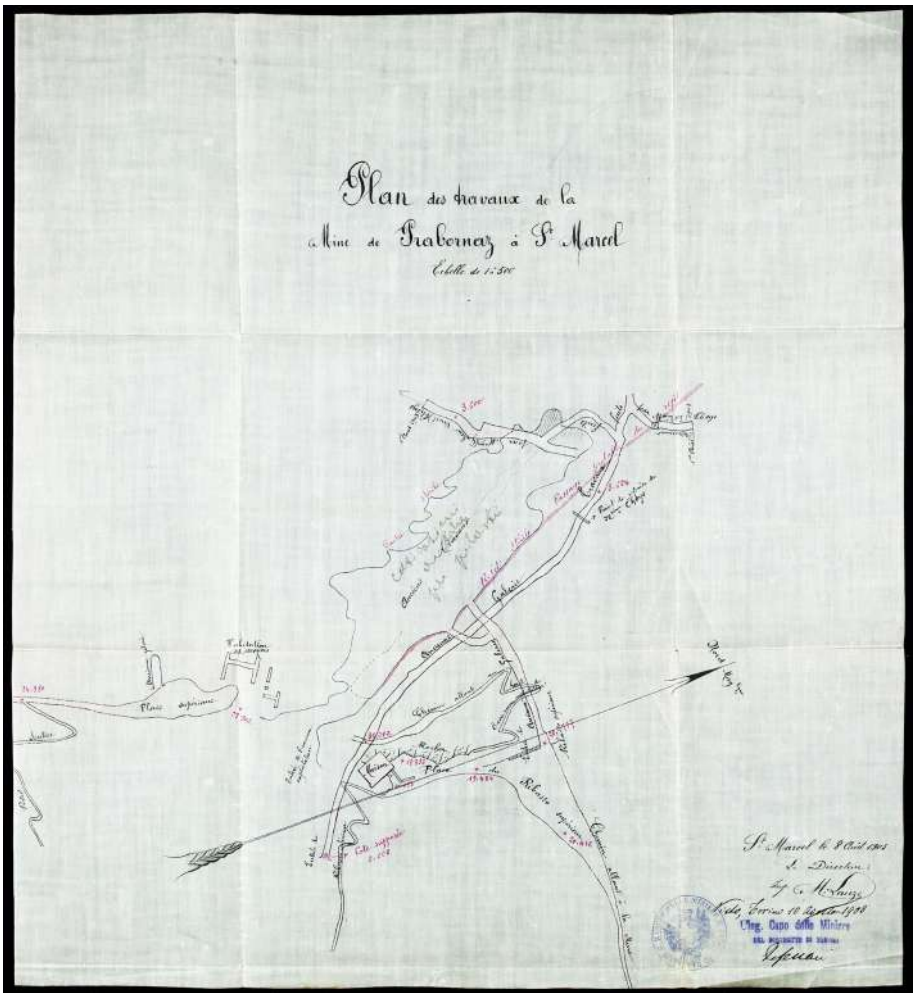

Figure 1.9. «Plan of the works at the Prabornaz mine in St Marcel». Map dated 8 August 1903.

AST SC, Distretto Minerario del Piemonte, Terzo versamento, Piani di miniera, mazzo 15, fascicolo 39.

a new map of the required concession dated 7 January 1903[89] (Fig. 1.8) and an updated mine plan dated 8 August 1903[90] (Fig. 1.9). The concession map outlines ambitious projects, including a 900-metre-long winze inclined at a 30° angle to the NNW, which would have connected four horizontal gallery levels, the lowest being located at a depth of 420 metres (Fig. 1.8). Alfred Theys and his team of engineers considered that the mineralised level outcropping between Praborna and Rualla forms a relatively regular plane inclined at 30° towards NNW, and is therefore worth exploiting at depth. However, this optimistic view was challenged by the fact that, although the mineralisation potentially occupies a regular plane, it consists of highly discontinuous lenses. As shown in the mine plan, the exploited lens is limited by «sterile parts», especially to the ENE, where engineer Marius Lauze identified a probable fault. Incidentally, it seems that the dewatering galleries excavated from 1901 to 1903 (shown in yellow in Fig. P.4) were also used to evaluate the extent of mineralisation in various directions, yielding disappointing results.

The engineers in Turin were not convinced by Alfred Theys' project, so they did not act on the request to expand the concession. By 1905, the mine had been abandoned for over two years[91]. On 8 August 1907, a ministerial decree gave one year's notice for the resumption of work[92]. On 3 May 1909, the *Consiglio delle miniere* decided to revoke the concession[93]. Alfred Theys requested the annulment of the revocation decree, but the council rejected it on 7 March 1910[94]. What the council members were unaware of was that the quantity of manganese produced in Italy for the steel industry would increase sevenfold in 1915 due to Italy's entry into the war[95]. However, by 1915, the Praborna mine had been abandoned for over a decade and all the easily accessible ore had been exhausted. Alfred Theys and his associates focused their efforts on exploiting the iron mines of Cogne, where they enjoyed a greater success[96].

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[89] AST SC, Distretto Minerario del Piemonte, Terzo versamento, Piani di miniera, Mazzo 15, fascicolo 39: *Commune de St Marcel. Mines de manganèse de Prabornaz. Plan du projet de travaux à exécuter devant servir pour la demande d'extension de la concession*.

[90] *Idem*: *Plan des travaux de la mine de Prabornaz à St Marcel*.

[91] «Rivista del Servizio minerario nel 1905». Tip. Nazionale Bertero, Roma 1906, p. 382.

[92] «Rivista del Servizio minerario nel 1907». Tip. Nazionale Bertero, Roma 1908, pp. 431, 433.

[93] «Rivista del Servizio minerario nel 1909». Tip. Nazionale Bertero, Roma 1910, p. 430.

[94] «Rivista del Servizio minerario nel 1910». Tip. Nazionale Bertero, Roma 1911, p. CLXVII.

[95] «Rivista del servizio minerario nel 1915». Tip. Nazionale Bertero, Roma 1917, p. CXXXIII.

[96] P.A. Farinet, *La miniera di Cogne: I precursori,* Tipografia Edoardo Duc, Aosta 1922,

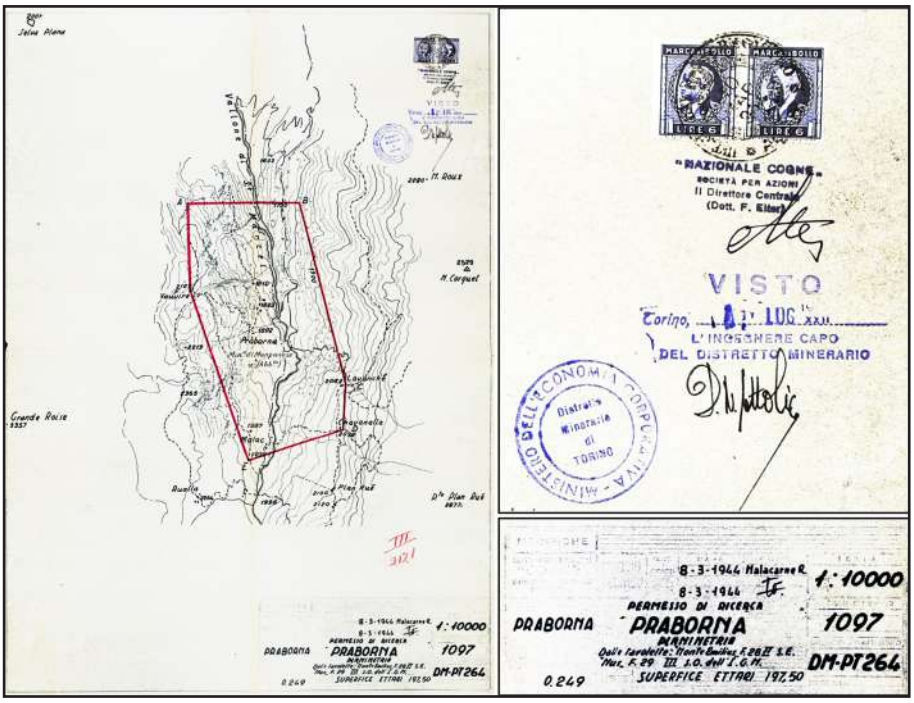

Figure 1.10. Map presented in support of an application for a manganese exploration permit at Praborna, dated 8 March 1944.

The details show that the document was signed by Franz Elter, the director of the Cogne iron mine and a prominent figure in the resistance against Nazi-fascism. Despite bearing tax stamps with the effigy of King Vittorio Emanuele III, the document was validated by an official of the Italian Social Republic, the fascist state established by Mussolini during the war.

AST SC, Distretto Minerario del Piemonte, Terzo versamento, Piani di miniera, mazzo 15, fascicolo 39.

Interest in manganese increases in times of war. In 1941, the *Società Anonima Costruzioni Brambila*, which operated the Chuc and Servette copper mines in Saint-Marcel, was granted a licence to prospect for manganese in the Praborna area. Giuseppe Chasseur, a miner, provided testimony about his work in Praborna during that period[97]. However, the Turin mining district engineer noted in his 1942 report that «the permit remained completely inactive again this year»[98]. The Turin State Archives contain a curious map dated 8 March 1944[99], produced in support of another application for an exploration permit for manganese in Praborna (Fig. 1.10). This document was signed by Franz Elter, who was the director of the Cogne iron mine, then operated by the *Società Anonima Nazionale Cogne*. Elter was a prominent figure of the Resistance against Nazi-fascism in the Aosta Valley. Curiously, the document was also signed in Turin by an official of the Italian Social Republic, the fascist state established by Mussolini during the war. Thus ended the mining history of Praborna, amid the chaos and tragedy of the Second World War.

1.3 Arsine, Varenche and other manganese occurrences

Prospecting for manganese was undertaken in several localities near Saint-Marcel from 1863 to 1886 (Fig. 1.11), possibly in anticipation of the exhaustion of the resource at Praborna. Search permits were also granted between 1941 and 1950, undoubtedly in response to manganese shortages linked to the Second World War. All of the prospected sites are geologically similar to Praborna and contain braunite-bearing ore. However, they proved to be negligible and unproductive, except for Arsine (Châtillon) and Varenche (Saint-Barthélemy, Nus), which are presented briefly here.

Significant concentrations of manganese ore have been reported in Arsinaz, also known as Arsine, near Promiod in Châtillon (45.792° N, 7.632° E), since the 18th century. On 22 December 1788, Jean-Claude Brunod confessed

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16 pp.; C. Binel, *La sidérurgie italienne pendant l'entre-deux guerres et la société des aciéries électriques «cogne»*, in «Cahiers du Centre de recherches historiques», 1988 (1), 21 pp.; http://journals.openedition.org/ccrh/2973; DOI: 10.4000/ccrh.2973.

97 A. Barzarsi, G. Zublena, *Le Miniere*, in «La Luge, Saint-Marcel», 1993 (n° 3, giugno), pp. 3-5.

98 [Ministero delle Corporazioni, Corpo Reale delle Miniere], *Relazione sul Servizio Minerario e Statistica delle Industrie Estrattive in Italia nell'anno 1942,* vol. 53 (68), Istituto poligrafico dello Stato, Roma 1947, p. 841.

99 AST SC, Distretto Minerario del Piemonte, Terzo versamento, Piani di miniera, Mazzo 15, fascicolo 39: *Permesso di ricerca 1944.*

period	municipality	localities	applicants	sources
1863-1886	Torgnon	Praz de Tarp; Desay; Pezzai	Vittorio Bich*; Frutaz Vittorio Emanuele; Domenico Tarro	1, fasc. 33
1866-1885	Nus	St-Barthélemy (Varenche, Genebrune)	Leandro Cristiani; Pierre Jaquemet	1, fasc. 55
1872-1879	Verrayes	Héry	Gioachino Raineri	2, fasc. 870**
1873-1875	Châtillon	Borgeant (near Saint-Vincent)	Giorgio Felice Brunod; Giovanni Battista Brunod	1, fasc. 20
1875	Verrayes	Goilles	Francesco Zannetti	1, fasc. 435
1876-1883	Châtillon	Arsine or Arsinaz	Pietro Andruet	1, fasc. 899
1879-1883	Verrayes	Diemoz or Cron	Giovanni Vignola; Domenico Vignola; Martino Verna	1, fasc. 982
1883-1885	Oyace	Rondelle	Giovanni Battista Gross	1, fasc. 1085
1884-1886	Saint-Marcel	Les Balmes	Louis de Peccoz	1, fasc. 1141
1941-1948	Châtillon	Arsine or Arsinaz		3, fasc. 3
1944	Saint-Marcel	Praborna	Società Anonima Nazionale Cogne	4, fasc. 39
1946-1948	Nus, Chambave	St-Barthélemy ***		3, fasc. 17
1946-1950	Aosta			3, fasc. 15

Figure 1.11. Research permits for manganese in the Aosta Valley issued by the Italian state (thus, after 1861).

Sources:

1, AST SC, Distretto Minerario del Piemonte, Primo versamento, Piemonte, Miniere, Permessi e concessioni, Provincia di Torino, mazzo 74;

2, *idem*, mazzo 78;

3, AST SC, Distretto Minerario del Piemonte, Primo versamento, Valle d'Aosta, Miniere, Permessi di ricerca, mazzo 154;

4, AST SC, Distretto Minerario del Piemonte, Terzo versamento, Piani di mineria, mazzo 15.

* In 1863, Bich also made a research request for Cu at Desay.
** See also 1, fasc. 982.
*** Request also for Cu and Fe.

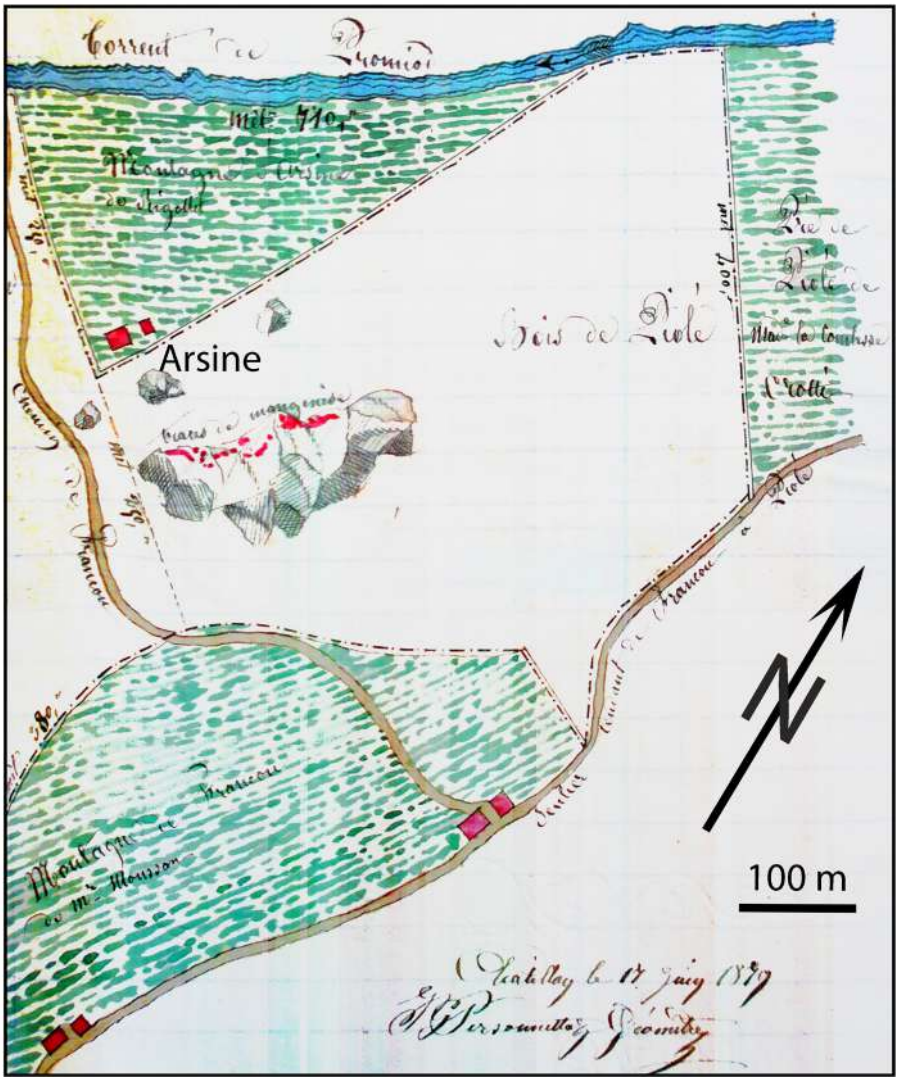

Figure 1.12. Map of the Arsine manganese occurrence, in Châtillon (1879).

The braunite occurrence is marked in red («traces de manganèse») to the east of Arsine (also known as Arsinaz and Arpine), in the Bois de Piolé, near the Promiod River («torrent de Promiod»). Meadows, forests, houses, pathways and rivers are shown in green, light grey, red, brown and blue, respectively. The area of the search licence requested by Pierre Andruet is outlined by a dash-dotted line.

Modified from AST SC, Distretto Minerario del Piemonte, Primo versamento, Piemonte, Miniere, Permessi e concessioni, Provincia di Torino, mazzo 74, fascicolo 899; «Châtillon, le 17 juin 1879, J.B. Personnettaz, géomètre».

to having extracted, at the request of Joseph Martinet of Verrès, 400 rups of manganese from a property belonging to the Count of Challand in Arsinaz and transported it to Verrès[100]. A century later, from 1876 to 1882, Pierre Andruet conducted a search for manganese in the same area and obtained an exploration permit on August 1879[101] (Fig. 1.12). However, it does not appear that this resulted in any significant mining activity. In addition to braunite, Auguste Engasser refers to the presence of rhodonite in this deposit[102].

The former Varenche manganese mine, also known as Genebrune, Issologne and Saint-Barthélemy, is located north of the Dora Baltea river, within the municipality of Nus (45.789° N, 7.488° E). The site is renowned among mineralogists for the diversity of manganese minerals it contains, and it shares many geological and mineralogical similarities with the Praborna mine[103]. Its history can be traced through two sources: a file in the Turin State Archives containing numerous documents from the period 1862-1885[104], and an article by Pelloux, who gathered information on site in 1922[105]. As these sources frequently contradict each other, the former is preferred here, as the information of the latter is not first-hand. Mining operations were carried out from April 1862 until the end of 1878 by Léandre Cristiani, a doctor from Aosta who was also known for his vehemently anti-clerical contributions to the weekly

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[100] FC 236-51.

[101] AST SC, Distretto Minerario del Piemonte, Primo versamento, Piemonte, Miniere, Permessi e concessioni, Provincia di Torino, mazzo 74, fascicolo 899; *Relazione sul Servizio Minerario* nel 1881 in «Annali di Agricoltura», 1883, n° 66; nel 1882, *idem* 1884, n° 72; nel 1883, *idem* 1885, n° 85.

[102] A. Engasser, *Minéraux de la Vallée d'Aoste collectionnés au musée de la Flore*, in «Société de la Flore Valdôtaine; Bulletin», vol. 16, 1923, pp. 24-44 [p. 37].

[103] G. Pagani, *Località mineralogiche consigliate. Varanche-St. Barthélemy (Lignan-Aosta)*, in «Notizie del Gruppo Mineralogico Lombardo», vol. 4, 1973, pp. 82-84; C. Baldelli, G.V. Dal Piaz, R. Polino, *Le quarziti a manganese e cromo di Varenche-St. Barthélemy, una sequenza di copertura oceanica della falda Piemontese*, in «Ofioliti», vol. 8 (2), 1983, pp. 207-222; A.A. Barresi, U. Kolitsch, M.E. Ciriotti, P. Ambrino, R. Bracco, E. Bonacina, *La miniera di manganese di Varenche (Aosta, Italia nord-occidentale): Ardennite, arseniopleite, manganberzelite, pirofanite, sarkinite, sursassite, thortveitite, nuovo As-Sc analogo della metavariscite e altre specie*, in «Micro [Periodico dell'AMI Associazione Micromineralogica Italiana]», 2005, pp. 81-122; also refer to several other entries in the bibliography.

[104] AST SC, Distretto Minerario del Piemonte, Primo versamento, Piemonte, Miniere, Permessi e concessioni, Provincia di Torino, mazzo 74, fascicolo 55.

[105] A. Pelloux, *Miniere e minerali manganesiferi della Valle d'Aosta*, in «Rendiconti dei lavori dell'Ufficio invenzioni e ricerche; vol. I. *Giacimenti Italiani di minerali accessori per la siderurgia*», Tip. del Senato, Roma 1922, pp. 22-38.

periodical *Le Constitutionnel Valdôtain*. The mine was never officially granted a concession; instead, Dr Cristiani obtained an exploration permit that was renewed no fewer than eight times for periods of one or two years. This procedure was essentially a favour granted by the mining engineers of Turin to the entrepreneur, as it allowed him to avoid paying royalties for an unprofitable mine. Indeed, from 1862 to 1867, only 88.1 metric tonnes of ore were extracted and sold for a total of 4530 *lire*, while during the same period the costs, including miners' wages, ore transportation and various infrastructure works, amounted to 21031 *lire*.

The mining engineer's report from his visit on 3 October 1867 provides interesting details about the mine. The deposit comprises three main lenses of manganese oxide within a quartz matrix. These lenses are interbedded within schists and are located around 50-60 meters from the serpentinite contact. The lenses are crosscut by veins of quartz and carbonates, coloured by manganese. The first lens, which has been excavated, measures approximately 10 metres in depth, 6.5 metres in width and 2.5 metres in height. The second is 11 metres wide and 5.65 metres high; and another is 4.5 metres wide and 3.35 metres high. At the mine entrance, there was a hut for the miners, a small forge for repairing tools and a platform for collecting ore. The mine employed ten miners, divided into two teams of five, as well as four carters to transport the ore to Nus. Although the mine was accessible all year round, it was inhabited and operational for only a few months each year. Two analyses of the ore revealed that it contained 33-35 wt.% manganese oxide and 55-64% siliceous gangue[106].

Another report, dated 14 September 1878, states that «the small amount of mineral found has already been fully excavated and exported». This was the reason why the research permit granted to Dr Cristiani was not renewed. However, this did not dissuade Pierre Jacquemet of Bard from submitting a new application for a research permit, seven years later, in August 1885 (Fig. 1.13). The permit, valid for a period of two years, was granted on 15 September of that year.

Pelloux (1922)[107] reports that Maurizio Fascio began exploiting the mine in 1902, by excavating a short gallery to the north of the old workings, where he found only traces of braunite. Between 1903 and 1904, Fascio also reworked

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[106] V. Cauda, *Minerali italiani analizzati nel Laboratorio di chimica docimastica presso la Scuola d'Applicazione per gli Ingegneri*, in «Atti della R. Accademia delle Scienze di Torino», IV, Appendice, 1868-1869, 107 pp. [pp. 24-25].

[107] A. Pelloux, *Miniere e minerali manganesiferi della Valle d'Aosta*, cit.

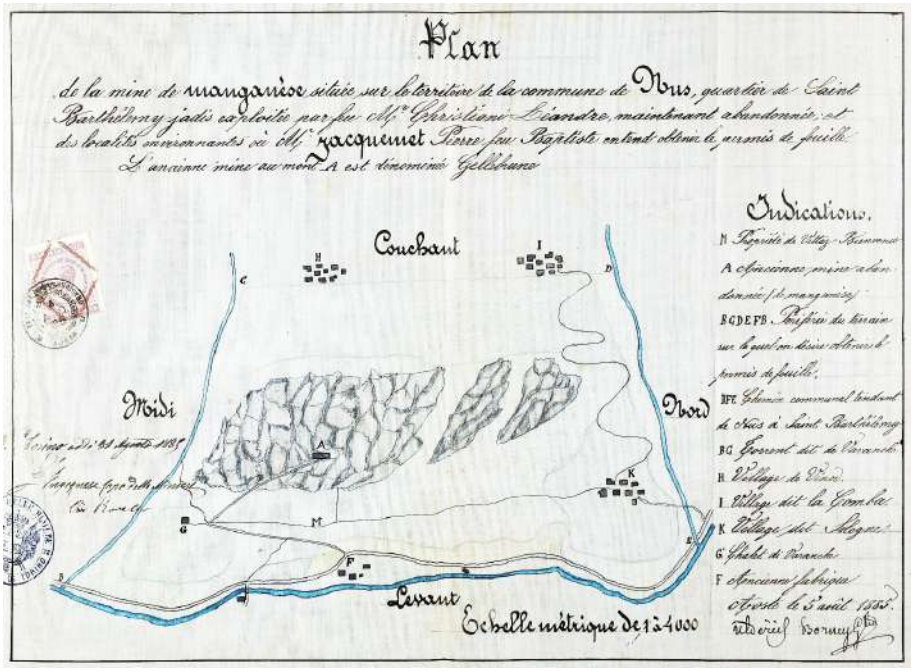

Figure 1.13. Map of the Varenche manganese occurrence, in Saint-Barthélemy, Nus (1885). Translation from French:

> «Plan of the manganese mine located in the municipality of Nus in the district of Saint-Barthélemy. The mine was formerly operated by Mr Christiani Léandre and is now abandoned. The plan also shows the surrounding localities where Mr Pierre Jacquemet, son of the late Baptiste Jacquemet, intends to obtain an excavation permit. The old mine on Mount A is called Gellebrune. […] Aosta, 5 August 1885».

AST SC, Distretto Minerario del Piemonte, Primo versamento, Piemonte, Miniere, Permessi e concessioni, Provincia di Torino, mazzo 74, fascicolo 55.

the previous mine debris, collecting poor-quality braunite which he sold to Venetian glassworks. The mine was then abandoned. However, in 1916 Alberto Ferrero of Turin obtained a licence to prospect for iron and manganese in the Saint-Barthélemy territory, and another research permit was granted between 1946 and 1948 (see Fig. 1.11). Both of these were apparently unsuccessful.

The galleries, which open onto a cliff, are now very difficult to access. Their precise descriptions can be found in Pelloux and Piccoli *et al.*[108]. Recently, ancient mining spoils have yielded many interesting minerals, the discovery of which has led to several publications, mentioned in the bibliography. We will present these briefly in the mineralogical chapter.

[108] A. Pelloux, *Miniere e minerali manganesiferi della Valle d'Aosta*, cit.; G.C. Piccoli, G. Maletto, P. Bosio, B. Lombardo, *Minerali del Piemonte e della Valle d'Aosta*, XV, Associazione Amici del Museo F. Eusebio, Alba 2007, 607 pp. [p. 289].

Chapter 2

The manganese trade, from Praborna to Venice and the rest of Europe

As we have seen, the Praborna manganese mine had a chaotic and eventful history from 1402 to 1903. During these five centuries, it was the subject of numerous lawsuits and disputes, suggesting that it was a valuable and coveted source of income. However, the archives reveal that mining techniques were basic and ore production modest. In fact, the ore was intended solely for use in the glass industry, which required only a small amount of it. Thanks to the numerous trade contracts preserved in the archives, especially those of the Challant family, we can trace the route, quantities and costs of manganese ore transported from the Praborna mine to glassworks in Venice or elsewhere.

2.1 A niche trade

First, let us say a few words about the ore and its use. Prior to 1800, it was referred to in all documents as «manganese» with various different spellings, and was said to be among the finest in Europe[1]. Excavations visible today show that it was sourced from the core of lenses rich in braunite, a black manganese oxide. This is confirmed by a description from 1857 by the mine engineer Despine[2]: «the ore is compact, with scaly fractures, blackish-brown in colour». This ore was rich in silica, primarily because braunite, unlike pyrolusite, contains a small amount of silica (ca. 9.9 wt.% SiO_2), but also because it is associated with quartz. A chemical analysis of an ore sample conducted on 14 April 1857 revealed that it contained 3.6 wt.% CO_2, 59.3% MnO_2, and 37% of other components, mainly SiO_2[3]. Due to its high

https://doi.org/10.14672/QUAD2026-47-3

[1] E.g., Report by Nicolis de Robilant on 10 December 1756 (AST SR, Ufficio generale delle finanze, Seconda Archiviazione, Miniere, Capo 20, Mazzo 7); S.B. Nicolis de Robilant, *Extrait d'un mémoire de M. Robilant sur la minéralogie du Piémont, considérée simplement sous le point de vue économique, où l'on trouve l'indication des mines et carrières de ce pays*, in «Journal des Mines», an VII [1798-1799], (Numéro L. Brumaire), pp. 81-164.

[2] FD 11 J 738.

[3] FD 11 J 738; see also the analyses of the braunite from Saint-Marcel by Ewreinoff, *Ueber die chemische Zusammensetzung des Heteroklin*, in «Annalen der Physik und Chemie», vol.

silica content, the ore was used to make glass, which contains a lot of silica anyway. During the 19th century, other potential applications were explored, including the production of chlorine or steel. In 1887, a small quantity of the ore was exported to Le Creusot in France for use in manganese-bearing cast iron[4]. However, the silica and carbonate contents were not favourable for these uses. In 1847, Asciano Sobrero indicated that, as the manganese oxide was almost exhausted, a new application had emerged that made the remaining ore more valuable[5]: when reduced to powder and mixed with a specific cement, epidote and other manganese silicates could be used to decorate walls to imitate polished stucco. However, this use remained apparently anecdotal. In short, the ore could only be used in small amounts to make glass. The end of the Praborna mine was inevitable, when lead glass gradually replaced manganese-bleached *cristallo* from the 18th century onwards.

Under the Challants, contracts were usually drawn up as follows: the seller – a member of the Challant or the Perrone families – agreed to deliver a certain number of rups of «manganese» all at once or in annual instalments. To avoid competition between the customer and the seller or between customers, contracts often included a clause that prohibited one party from selling in the same region as the other. On 31 May 1719, for example, Baron Joseph-Félix and Count Georges-François de Challant signed a contract with Bartolomeo Molinati and Domenico Amosso, who were citizens of Ivrea, to deliver 4000 rups (approximately 38 tonnes) of manganese each year, over a period of six years, for sale in Venice. The Challants agreed not to sell manganese to anyone else for eight years, except to Maurice Miedangros of Hauteville-en-Tarentaise (Savoy), with whom they had already concluded a contract on 10 September 1714 for the sale of 2000 rups of ore annually for eight years, intended for the French market. Molinati and Amosso also agreed not to export manganese to France during the same period[6]. In return,

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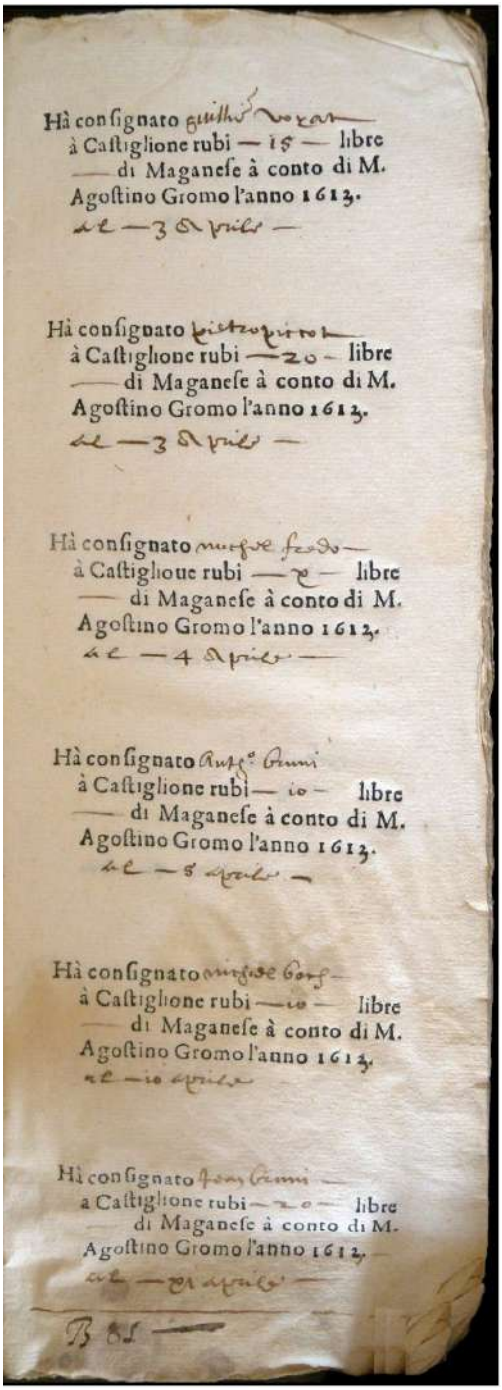
125, 1840, pp. 204-210, and A. Damour, *Analyses de la marceline*, in «Annales des Mines», (4ème sér.) vol. 1, 1842, pp. 400-408.

4 *Rivista del Servizio minerario nel 1885*, Tip. di G. Barbèra, Firenze 1887 [p. 248].

5 A. Sobrero, *Relazione del viaggio fatto dal dottore Ascanio Sobrero nei mesi di luglio ed agosto 1846 nella Valle d'Aosta e nella Savoia*, Stamperia Reale, Torino 1847, 60 pp. [p. 39].

6 FC 168-28. There are several other examples of this type of clause: A contract with Lombard merchants, dated 10 December 1611, stipulates that «*detto ill[ustrissi]mo s[ignor] Chialant non possi far contrato con altri ne debitare e vender la mercantia sudetta dal canto della Lombardia e Italia tutta cominciando dal logo dove si cava detta matteria*» (FC 161-1B). Another contract dated 1643 between Carlo Filippo Perrone and François-Jérôme de Challant


Hà consignato guillio voyar
à Castiglione rubi — 15 — libre
— di Maganese à conto di M.
Agostino Gromo l'anno 1613.
adi — 3 Aprile —

Hà consignato pietro pirron
à Castiglione rubi — 20 — libre
— di Maganese à conto di M.
Agostino Gromo l'anno 1613.
adi — 3 Aprile —

Hà consignato nicolo fredo
à Castiglione rubi — 2 — libre
— di Maganese à conto di M.
Agostino Gromo l'anno 1613.
adi — 4 Aprile —

Hà consignato Antº Ormi
à Castiglione rubi — 10 — libre
— di Maganese à conto di M.
Agostino Gromo l'anno 1613.
adi — 5 Aprile —

Hà consignato nicolo Gorf
à Castiglione rubi — 10 — libre
— di Maganese à conto di M.
Agostino Gromo l'anno 1613.
adi — 10 Aprile

Hà consignato Jean Ormi
à Castiglione rubi — 20 — libre
— di Maganese à conto di M.
Agostino Gromo l'anno 1613.
adi — 21 Aprile —

B 85

Figure 2.1. Page from a manganese register showing deliveries made to Castiglione (Châtillon) in the name of Agostino Gromo in April 1613.

Translation from Italian of the first receipt: «Guillie [lmo] Voyat delivered to Castiglione [Châtillon] 15 rups, [0] pounds of Maganese on behalf of Mr Agostino Gromo, in the year 1613 on 3 April» (FC 165-9).

Figure 2.2. One page of the delivery receipts for manganese from 26 November to 29 December 1702.

Note that the bills on the right-hand side have been cut out and kept by the deliverers. The coat of arms belongs to Joseph-Félix de Challant, Baron of Castiglione (Châtillon). The second receipt, for example, can be translated as follows: «N° 37, on 26 December 1702, at the Coni factory [Conoz, Châtillon], Martin Voÿen delivered manganese belonging to the most illustrious Mr Baron of Castiglione. Mr Belotto will be pleased to pay him 8 lire 15 soldi for carrying 350 rubbi of ore from the vein to the factory at 6 dinari per rubbo.» (FC 165-39).

on 16 May 1719, Miedangros committed himself not to sell manganese in Italy[7]. The Challants, for their part, accepted not to ship it to France, Germany, Switzerland or Savoy. Other clauses may allow the contract to be temporarily suspended in the event of «contagion» or war, as set out in the above contract dated 31 May 1719[8].

The price was set at a certain number of *sols* (or *soldi*) per rup (or *rubbo*) of manganese. The seller then made agreements with local people for the extraction of the ore and its transportation to the valley, where it was handed over to the customer's agents. Those employed for these tasks often came from Saint-Marcel, particularly from Seissogne, the nearest village downstream from Praborna; they often belonged to the same families for generations. The Challants usually hired someone to organise the extraction and transportation of the «manganese» to the valley. Remunerations were agreed based on the quantity extracted or transported. Finally, when the Challants were unable to organise the mining and transportation of the ore themselves, they could rent the mine out to the customer, although this remained exceptional[9].

Mining was seasonal, which is unsurprising given the altitude of ca. 1920 metres and the climatic conditions of the Little Ice Age. Evidence of this practice can be seen in a few contracts with the head miner and the mine workers – usually four or five –, which took effect in spring, and ended with their dismissal and the consignment of their tools in autumn. The inventory

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stipulated that the latter should not extract «manganese» for sale in Piedmont or Venice for 14 years, but would have the right to do so in countries beyond the Alps (FC 49-1). On 22 May 1671, François-Jérôme de Challant sold 1300 rups of manganese to Antoine Piana of Ivrea, who agreed that «*tal maganese non lo possi far condurre da altra parte che dal latto dell'Itaglia*» (FC 161-1B). On 25 October 1705, Joseph-Félix de Challant added the following note to a contract with Joseph Flandrin: «*Je promet de ne point vendre de manganés du costé d'en haut, c'est a dire qui puisse passer depuis le mont Cervin jusques au grand et petit St Bernard jusques au premier Jeanvier 1710.*» (FC 161-1G).

[7] Amendment to the contract of 10 September 1714 (FC 161-1K; FC 90-37). In December 1737, Joseph Davise purchased manganese in Tarentaise (Savoy) with the intention of reselling it in Ivrea, which could be seen as a violation of this clause. The Baron de Châtillon had the manganese seized in Verrès, but then lifted the seizure on the orders of the vibailiff of the Duchy of Aosta (FC 164-22; FC 165-50, letter of 21 December 1737; FC 165-65).

[8] Such a suspension is intended «*in caso di peste, o guerra guereggiata in Italia o altrove, o prohibitione di qualche sovrano…*» (FC 166-28). Other examples: FC 161-1B (1611); FC 161-1J (1714); FC 161-1V (1752).

[9] FC 161-1A (1596); FC 161-2B (1600); FC 161-13 (1641); FC 166-9 (1673); FC 165-50 (1747); FC 236-48 (1750).

of these tools sheds light on the fairly basic mining techniques employed. The 1707 inventory included forge bellows, two pairs of pliers, a «hammer suitable for working iron», thirteen crowbars, two «*calcaterras*», six wooden mine boxes («*baquettes*»), a pickaxe, three mining hammers, a mallet, an iron lever («*palfer*»), a pick, a wedge, a shovel and an iron file[10]. In 1706, the inventory also included a bag of coal and an axe. This indicates that a small forge was used to sharpen tools on site, and that ore was collected by hand using «*baquettes*». Documents from 1681, 1707 and 1722 also mention the use of gunpowder[11].

There have been complaints from customers regarding the poor quality of the «manganese», mixed with «marble» and «stones»[12], which is hardly surprising given that local employees were paid based on how much ore they collected and transported. Some contracts, such as that of 1681[13], instructed the chief miner to carefully sort the ore, «as the cavity of the mine is filled with bad stones»; he was advised to «throw the bad stones outside the said cavity, down the cliff», in order to «separate the ore from the stone». These «bad stones», found in the debris at the bottom of the slope, are now highly valued by mineralogists.

The manganese was transported on muleback from the mine to Dora Valley by muleteers, who returned with supplies for the miners. During certain winters, sledges were also used to transport some ore stored in a warehouse in Seissogne – this is attested for the winters of 1706-1707 and 1714-1715[14]. Depending on the period and the contract, the ore was transported to Saint-Marcel castle or the Châtillon factories, and from there to Ivrea or Aosta. In the 19th century, the ore was stored in a warehouse located between Praborna and the Servette copper mine[15], before being transport-

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[10] FC 165-41 (1706-1707) and FC 165-43 (1707).

[11] FC 161-1D; FC 165-41; FC 334-47.

[12] «*resta necessario che V.S. Ill[ustrissi]ma dia ordine à persona esperta ch'alla Balma facci la separatione del marmo del maganese perché non torna a conto ne a luoro S[ignor]i ne à noi pagare la condotta di quella materia che serve a niente [...,] avendo ritrovato il maganese che qui ha mandato quasi la mettà pietre e marmo, il che [...] a Venetia non lo vogliono...*» (Ivrea, 18 luglio 1719: FC 165-52). Also see: B. Bonvoisin, *Vues économiques sur la culture des produits du règne minéral en Piémont*, in «Journal des Mines», 11 (LXI, vendémiaire), an X [1801-1802], pp. 3-34 [Praborna: pp. 22-23].

[13] FC 161-1D.

[14] FC 161-1I; FC 161-1J.

[15] A map from May 1860 (*Plan démonstratif...*, AST SC, Distretto Minerario del Piemonte,

ed to the Bordon family home in Nus. An attendant was responsible for receiving, weighing and registering on *billettes* the manganese ore (Figs. 2.1 and 2.2). Thus, in 1719, Vincent Rigollet, an employee at Saint-Marcel Castle, was responsible for receiving and shipping the manganese brought by the muleteers, as well as keeping accurate records of it[16]. Unfortunately, these records have been lost over time, except for the period 1615-1620, for which precise delivery details are available[17]. The quantities received during these six years indicate an average annual production of 2787 rups (*i.e.*, 26.8 metric tonnes per year), with significant seasonal and yearly variations. For instance, it appears that no production occurred in 1616.

Comparing the wages of local employees with the sale prices charged to customers reveals that the Challants kept most of the income for themselves. For example, in 1704, Jean-Michel Pachié (Pasquier) was paid 4.5 *sols* per rup of «manganese» that he had extracted at Praborna and transported to Aosta, where it was sold to Joseph Flandrin for 14 *sols* per rup[18]. A few years later, between 1719 and 1725, Joseph-Félix de Challant organised the annual delivery of 4000 rups (equivalent to around 38.5 metric tonnes) of manganese to Molinati and Amosso in Ivrea, destined for Venice. Excavating and transporting 4000 rups from the Praborna mine to Saint-Marcel cost 800 *livres*, equivalent to 2.4 *sols* per rup. Vincent Rigollet was responsible for receiving the ore and managing the stock in Saint-Marcel at a rate of 16 *livres* for 1000 rups, equating to 0.19 *sol* per rup. Finally, Vincent Ferraz was paid two *sols* and two *deniers* per rup for transporting the manganese from Saint-Marcel to Ivrea, equating to 2.17 *sols* per rup[19]. Therefore, the cost price was 4.76 *sols* per rup of manganese delivered to Ivrea, where it was sold to Molinati and Amosso for 15 *sols* per rup. It thus appears that the Challants kept around two-thirds of the income for themselves. However, they had to use some of this revenue to buy equipment and gunpowder for the mine.

Terzo versamento, Piani di miniera, mazzo 15, fascicolo 40) shows the location of an «*entrepôt du manganèse*» approximately 450 m north of L'Étéley, on the western side of the pathway from Praborna to Servette (at circa 45.695 N, 7.452 E).

[16] Vincent Rigollet was paid sixteen *lire* for each thousand *rups* of ore (FC 161-1L).

[17] FC 165-11; FC 166-1bis; FC 162-4; FC 165-23.

[18] Sources: FC 161-1H; FC 161-1F; FC 307-1; FC 161-1G.

[19] FC 165-53, 161-1L, 161-1M, 166-28.

2.2 Manganese delivered to Venice

The ore delivered to Châtillon and Ivrea[20] (*i.e*., to the east of Saint-Marcel) was destined for glassworks in Turin[21], Biella, Milan and, in particular, Venice. In the years 1610, the manganese trade between the Aosta Valley and Venice was managed by Agostino Gromo from Biella and Giuseppe Desio from Milan[22]. From 1618 to 1670, it was handled by the Perrone family of Ivrea[23], and then between 1710 and 1741, by Molinati and Amosso of Ivrea, who formed a trading company with Georges-François and Joseph-Félix de Challant in 1720[24]. Unfortunately, the archives are missing after 1747, when the mine was operated by Jean-Baptiste Davise.

The use of manganese from Praborna in Venice is documented in several manuscripts from the Challant archives. In April 1612, Giovanni Marineto, a master glassmaker from Murano, issued a certificate stating that the Venetian glassmakers consumed up to 40 *migliara* of «piedmontese manganese» per year[25], equivalent to around 25 metric tonnes; the document was placed in a vellum envelope and sealed with the lead seal of Leonardo Donato, the Doge of the *Serenissima* Republic (Fig. 2.3). Another certificate, dated 23 December 1612, was issued by the master glassmakers Vincenzo dal Todescho, Iuanne alla testa d'oro, Lodovico alla Luna and other Murano glassmakers, who declared that they used approximately 35 «miara» (*migliara*) of manganese per year – equivalent to approximately 22 tonnes –, and that this mineral came from the Saint-Marcel mine[26]. In his *Relatione dello stato presente del*

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[20] FC 168-8 (1638-1642); FC 161-14 (1661); FC 161-18 (<1670); FC 161-17 (1670); FC 161-1C (1671); FC 161-19 (1671); FC 165-24 (1671); FC 166-10 (1673); FC 166-14 (1681); FC 161-1D (1681); FC 166-15 (1686); FC 164-4 (1689); FC 165-52 (1719-1741); FC 168-28 (1719); FC 161-1M (1719); FC 165-57 (1728); FC 161-1N (1730); FC 165-38 (1731-1736).

[21] In 1670, inhabitants of Turin declared that they had purchased manganese from the Saint-Marcel mine, sold by the barons Perrone (FC 161-16), and Antonio Sculdo, a glassmaker from Leyni, confirmed that he usually use manganese purchased in Ivrea (FC 161-17). Giovanni Giordano of Turin also purchased 7105 rups of manganese from 1687 to 1689 (FC 166-15, FC 166-16, FC 161-1E).

[22] FC 161-1B, 165-9, 161-4B, 165-6, 343-18, 161-6, 165-6, 165-14, 165-16, 161-4A, 165-18, 161-9.

[23] See in particular, FC 161-4A, 165-18, 161-4C, 161-10, 161-13, 161-14, 168-8, 161-18, 49-1…

[24] FC 165-52, 165-53, 166-28, 307-2, 161-1N.

[25] FC 165-5.

[26] «*il manganese [...] si caua nella Val di auosta [Aosta] nel luoco nominato S. Marcello di*

Figure 2.3. The lead seal of Leonardo Donato, Doge of Venice, affixed to a certificate dated 30 April 1612 and issued by Giovanni Morineto, master glassmaker in Murano.

Obverse: S.M.V.DUX.LEON[ARDUS].DONA[TO]; *reverse*: LEONARDUS.DONATO.DEI.GRA[TIA].DUX. VENETIAR[UM] E T. The document attests that Venice's glassmakers use forty migliara (ca. 25 metric tonnes) of manganese from Praborna every year (FC 165-5).

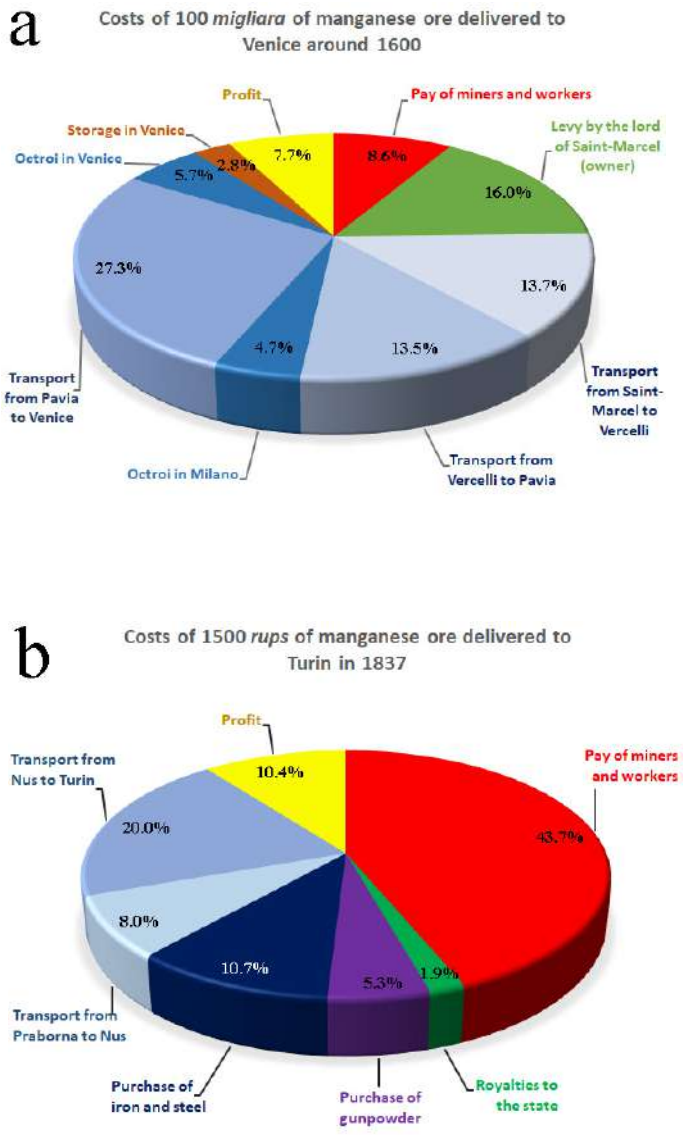

Figure 2.4. Manganese production costs.

a: Costs for manganese delivered to Venice around 1600 (FC 165-7).
b: Costs for manganese delivered to Turin in 1837 (FD 11 J 733).

Piemonte, published in 1635, Francesco Agostino Della Chiesa also mentions «Saint-Marcel […] where the powder to make glass and crystals, called manganese, is excavated»[27].

A document from the early 18th century[28] shows that the main cost of the ore delivered to Venice was transport (54.4%), to which were added octroi charges (tolls) at the entrances to Milan and Venice (10.5%) (Fig. 2.4a). Other expenses included the levy imposed by the Challants (16%), which was almost double the wages of local miners and workers (8.6%). There were indeed numerous tolls, octrois and custom duties, but tax exemptions could be granted, as suggested by a contract dated 5 May 1661 between Baron Perrone and Louys Réan. Responsible for extracting and delivering 4000 rups of manganese to Ivrea over a period of two years, Réan was «relieved of the custom duties due to S.A.R. [i.e. Charles-Emmanuel II] for the passage of such manganeys through the Bardese [?], with the other tolls remaining at Rean's expense»[29]. Duke Victor-Amédée, aware that «manganese is a suitable material for the manufacture of crystalline glass» and keen to encourage Venetian workers to come and extract this material in the Aosta Valley, granted special protection to those working at the Saint-Marcel manganese mines on 20 October 1632. He also exempted the Baron de Châtillon from all custom duties on exported manganese for 12 years[30]. However, it seems unlikely that any workers left the magnificent city of Venice to live in the harsh mountain pastures of Praborna.

A document drawn up by engineer Despine estimates the cost of 1500 rups of manganese collected in Praborna in 1837 and delivered to Turin (Fig. 2.4b), from where it could be distributed throughout Italy, including Venice[31]. Seven miners and workers were paid 820 *lire*, for four months of work at the mine. This sum must be increased by the cost of gunpowder, iron and steel (ca. 300 *lire*), as well as the cost of transporting the manganese ore from the mine to Nus in the valley (0.10 *lira*/rup, i.e. a total of 150 *lire*) and then on to Turin

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Riuiera in piamonte» (FC 161-6). The quantities given here in metric tonnes are estimates based on the assumption that the Venetian *migliaria* was equal to ca. 625 kg (see Notes).

[27] F.A. Della Chiesa, *Relatione dello stato presente del Piemonte*, G. Zavatta e G.D. Gaiardo, Torino 1635, in-4°, XVI-79 pp. [p. 60: «*S. Marcello […] oue la poluere da far vetri, e Cristalli detta Manganese si caua*»].

[28] FC 165-7.

[29] Translated from old French (FC 161-14).

[30] FC 166-2.

[31] FD 11 J 733.

(0.25 *lira*/rup, i.e. 375 *lire*). Additionally, yearly royalties of 3% on the ore's cost price at the mine must be paid to the Piedmont-Sardinian state – these were actually paid retroactively in 1841. Therefore, the cost price of a rup of ore delivered to Turin was 1.12 *lire* (1680 *lire* in total), where it was sold to drugstores for 1.25 *lire* (1875 *lire* in total).

It is interesting to compare the data from 1837 (Fig. 2.4b) with that from the early 17th century (Fig. 2.4a), as this reveals changes linked to the collapse of the feudal system. However, it is worth mentioning that the transport costs differ significantly between the two datasets, since the ore destinations are very different. For the earlier period, it is more accurate to consider only the cost of transport from Saint-Marcel to Vercelli, since this distance is similar to that from Nus to Turin. In any case, the modest tax levied by the state in 1837 replaced the exorbitant levy imposed by the lord of Saint-Marcel. However, it should be noted that, in the earliest period, supplies such as gunpowder and tools were the responsibility of the lord, whereas in the 1837 document, they are accounted for separately. Despite these uncertainties, it appears that the wages of local employees were relatively higher in the 19th century than in the 17th.

2.3 Manganese sent beyond the Alps

Ore transported westwards to Aosta in the Dora Valley, upstream of Saint-Marcel, was destined for countries beyond the Alps – particularly France –, passing through the Little Saint Bernard and Great Saint Bernard passes. Several clients from Aosta and further afield are named in the contracts and receipts of the Challant archives. In 1696, Sébastien Col purchased 730 rups of manganese in Aosta[32]. Joseph Flandrin of Aosta acquired 600 to 1000 rups per year from 1696 to 1708[33]. A few years later, from 1714 to 1729, Pierre Miedangroz and his associates from Hauteville-en-Tarentaise and Bourg-Saint-Maurice (Savoy) received 2000 rups per year[34]. Monsieur de Normandie, a Geneva merchant, received deliveries in 1719[35]. On 25 April 1727, Germain Novallet wrote from Lyon to Count Georges-François de Challant regarding the shipment of Praborna manganese to Paris for the *Manufacture des Glac-*

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[32] Nearly 7 metric tonnes: FC 165-26.

[33] 5.8 to 9.6 metric tonnes per year: FC 161-1F, 165-36, 165-38, 165-35, 161-1G, 307-1, 161-1H, 161-1I, 165-42.

[34] 19.6 metric tonnes yearly: FC 161-1J, 165-47, 161-1K, 90-37, 334-47bis, 165-56.

[35] FC 165-47.

es[36]. Records are missing from 1747 onwards, by which time Jean-Baptiste Davise had taken charge of the mine. However, a letter, dated September 1747, states that Davise sent some «manganèse» to «Monsieur Mortier in Paris via Lyon»[37].

These sources clearly show that Piedmont manganese only became significant in the French market from the end of the 17th century, several centuries after the first deliveries to Venice. This development was indeed linked to the establishment of the *Manufacture royale des Glaces* in 1665 by Jean-Baptiste Colbert, who was minister to Louis XIV[38]. Although the Saint-Gobain company, which succeeded the royal factory, lost most of its archives during the First World War, some still survive in Blois, France. Purchases of manganese appear in several of the factory's accounts between 1685 and 1799[39]. A 1769 report details its use at Saint-Gobain and states that «although each country praises its own, manganese from Piedmont is generally considered to be the best»[40]. Above all, the letters written by Novallet and Davise in 1727 and 1747 clearly demonstrate the link between the manganese sold in Aosta and that purchased in Paris or Saint-Gobain. Therefore, it is likely that the glass in the Hall of Mirrors at Versailles contains a little manganese from Praborna.

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[36] FC 134-10.

[37] FC 165-50.

[38] E. Frémy, *Histoire de la Manufacture royale des glaces de France au XVII^e^ et au XVIII^e^ siècle*, Plon-Nourrit et Cie, Paris 1909, XII-445 pp.

[39] ASG FH 1H2-1 1695, 1706; ASG FH1H2-4 1712, 1730, 1750, 1752, 1759; ASG FH 1H3-1 1784, 1799.

[40] «*Organisation de Saint-Gobain en 1769. I-Fabrication*», ASG FH C22 [section «Maganèse», pp. 45-46].

Chapter 3

The use of «Piedmont manganese» in glassmaking

Whether delivered to Venice, Saint-Gobain or elsewhere, the Praborna manganese oxide was used to bleach glass, and was thus an essential component in the production of the precious *cristallo*. This chapter recounts the discovery and development of these techniques, which brought prosperity and fame to the glass industry in Venice for several centuries, and subsequently to the Saint-Gobain factory.

3.1 Manganese, the glassmakers' soap

Manganese makes glass transparent and colourless, and for this reason it has been nicknamed «glassmakers' soap». The use of manganese (or more precisely, of manganese dioxide) for this purpose has been known empirically since ancient times, even before the word «manganese» was coined in the Middle Ages. However, the process was not understood until the emergence of modern chemistry, when it could be explained by a simple chemical reaction between iron and manganese ions[1]:

$Fe^{2+} + Mn^{3+} \rightarrow Fe^{3+} + Mn^{2+}$.

Despite glassmakers' efforts to avoid it, divalent iron (Fe^{2+}) is naturally present in glass, giving it a greenish tint. It is well known that divalent iron absorbs visible light, resulting in the strong colouration of materials bearing Fe^{2+}, such as ferrous silicates. Manganic manganese (Mn^{3+}) can be added to the glass in the form of pyrolusite or as braunite in the case of the Praborna

https://doi.org/10.14672/QUAD2026-47-4

[1] R.J. Haüy, *Traité de minéralogie*, 1ère édition, Louis ed., Paris 1801, 4 vol. + atlas [in vol. IV, p. 171, Haüy correctly explains the decolourisation caused by manganese oxide releasing its oxygen]; C. Flagey, *Du Rôle que jouent les oxydes de manganèse et de cobalt dans la décoloration du verre*, in «Annales du Génie Civil», XVI, 1869, pp. 732-736; R. Dralle, *Die Glasfabrikation*, Druck und Verlag, Munchen und Berlin 1926, 2 bände [band 1, pp. 187-188]; K. Winnacker, L. Küchler, *Chemische Technologie. Band 2, Anorganische Technologie II*, C. Hanser, München 1959, XXIII-704 pp.; K. Nassau, *The Physics and Chemistry of Color. The Fifteen Causes of Color*, John Wiley & Sons, New York 1983, XX-454 pp.-[8] p. of plates. [p. 309]; B. Lockhart, *The Color Purple: Dating Solarized Amethyst Container Glass*, in «Historical Archaeology», 40 (2), 2006, pp. 45-56.

ore. The resulting Fe^{3+} and Mn^{2+} ions are almost colourless, so this reaction ideally makes the glass transparent and colourless if the amount of Mn^{3+} introduced is equal to the amount of Fe^{2+} present. Conversely, introducing an excess of Mn^{3+} relative to Fe^{2+} produces a red or purple hue in the glass, the intensity of which depends on the amount of excess Mn^{3+}. Therefore, depending on the dosage used, Mn^{3+} can either decolourise glass or tint it red to violet:

$(a+b)\ Fe^{2+} + a\ Mn^{3+} \rightarrow a\ Fe^{3+} + a\ Mn^{2+} + b\ Fe^{2+}$
(lack of Mn^{3+}: glass bleaching is incomplete);

$a\ Fe^{2+} + a\ Mn^{3+} \rightarrow a\ Fe^{3+} + a\ Mn^{2+}$
(saturation in Mn^{3+}: glass bleaching is optimal);

$a\ Fe^{2+} + (a+b)\ Mn^{3+} \rightarrow a\ Fe^{3+} + a\ Mn^{2+} + b\ Mn^{3+}$
(excess of Mn^{3+}: glass becomes red to violet).

In reality, ferric ion (Fe^{3+}) gives glass a very slight yellow tint. However, this light shade can be neutralised by a slight excess of Mn^{3+}, whose violet tint is almost complementary to yellow[2].

Luigi Zecchin[3] states that the earliest known written reference to «manganese» by name dates back to December 1290[4]: Guglielmo Deolay and Marco Pignaniga, who owned a furnace in Murano, Venice, were summoned to the *Podestà* of Murano regarding unpaid «Syrian alum» and, on 14 December 1290, the *Podestà* seized five baskets of «maganese» from Marco Pignaniga (Fig. 3.1). However, the origin of the word is unclear. It is generally thought to be the result of glassmakers corrupting and concatenating the two words «*magnesia nigra*» (black magnesia) to differentiate it from «*magnesia alba*» (white magnesia, i.e. our magnesia), which was also useful in glassmaking. Regardless of its origin, glassmakers used the term «manganese» to refer to natural manganese oxides rather than manganese metal, which was not isolated until much later, in 1774, by Johan Gottlieb Gahn.

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[2] C. Flagey, *Du Rôle que jouent les oxydes de manganèse et de cobalt dans la décoloration du verre*, cit.; K. Winnacker, L. Küchler, *Chemische Technologie*, cit.

[3] Luigi Zecchin has written dozens of essays on the history of glass, with a particular focus on Venetian glass. These essays have been collected and reprinted in three volumes, which constitute an invaluable reference work on the subject: L. Zecchin, *Vetro e vetrai di Murano. Studi sulla storia del vetro*, Arsenale editrice, Venezia 1987-1990, 3 vol., 366 + 390 + 403 pp.

[4] ASV, Podestà di Murano, busta 3; L. Zecchin, *Vetro e vetrai di Murano*, cit. [vol. 1, p. 239; vol. 2, p. 363; vol. 3, p. 7].

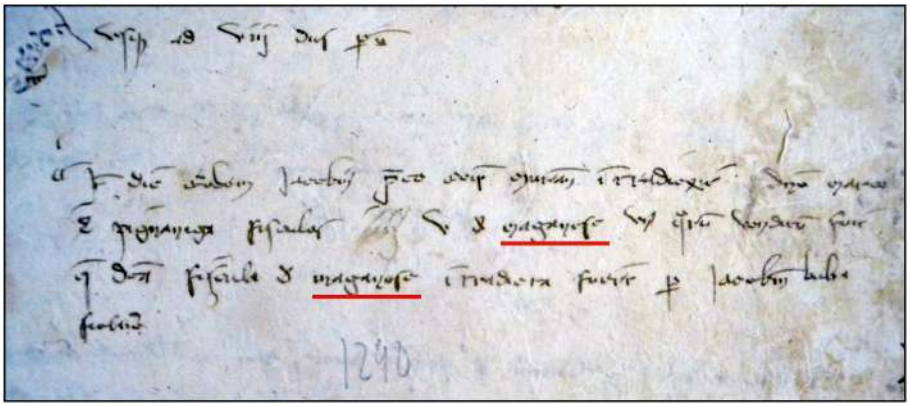

Figure 3.1. First occurrence of the word «maganese» in a Latin manuscript dated 14 December 1290 (ASV, Podestà di Murano, busta 3).

The document concerns the seizure of five baskets of manganese from Marco di Pignaniga (with resolution of the abbreviations: «fisculos [iiij deleted] v de maganese […] quae dicta fiscula de maganese intradicta fuerunt per Jacobinum Bulia fiolarium»).

See: L. Zecchin, *I primi "atti" dei podestà di Murano*, in «Giornale Economico della Camera di Commercio (Venezia)», XX, 1966, pp. 745-750; Id., *Vetro e vetrai di Murano. Studi sulla storia del vetro*, Arsenale editrice, Venezia 1987-1990, 3 vols. [I, pp. 237-241; II, pp. 360-368 ; III, pp. 5-47].

Manganese oxide may have been used as a glass bleaching agent long before the term «manganese» was coined in the Middle Ages. In chapters 65 and 66 of book XXXVI of his *Naturalis Historia*, completed around AD 77, Pliny the Elder discusses the formation of glass, the ingredients of which include sand, natron (or niter), and «*magnes lapis*», i.e. magnetite[5]. Luigi Zecchin suggests that the latter was actually black manganese oxide, mistaken for magnetite[6] – a possibility made more likely by the fact that manganese and iron oxides are often found together in nature. The use of manganese as a bleaching agent since antiquity has also been demonstrated through the chemical analysis of ancient glass artefacts[7].

Georg Bauer, known as Agricola (1494-1555), still mistakenly identifies manganese as magnetite, as evidenced by the following excerpt from the end of Book XII of his famous *De Re Metallica* (Fig. 3.2), published in 1556[8]: «Two parts of coarse or fine sand made from fusible stones should be mixed with one part of soda […], to which powdered magnetite is added. It is true that, today as in ancient times, it is believed that magnetite has the ability to attract the vitreous liquid to itself, just as it does with iron, and to purify and transform it from green or yellow to transparent»[9].

By contrast, Vannoccio Biringuccio, whose *De la Pirotechnia* (Fig. 3.3) preceded Agricola's *De Re Metallica* by sixteen years, definitely refers to manganese by name, which he probably learned about from the glassmakers

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[5] «*Mox, ut est ingeniosa sollertia, non fuit contenta nitrum miscuisse; coeptus addi et magnes lapis, quoniam in se liquorem vitri quoque ut ferrum trahere creditur.*» (As might have been expected, man's inventive skill was no longer content to mix soda with sand alone. He also began to introduce the magnet stone [i.e., magnetite], since it is believed to attract molten glass in the same way that it attracts iron).

[6] L. Zecchin, *Vetro e vetrai di Murano*, cit., vol. 1, pp. 279-288; L. Zecchin, *Vetro di Plinio*, in «Giornale Economico della Camera di Commercio (Venezia)», vol. V, 1951, pp. 13-18, 74-79.

[7] E.V. Sayre, *The intentional use of antimony and manganese in ancient glasses*, in F.R. Matson, G.E. Rindone (Eds.), *Advances in glass technology: technical papers of the 6th International Congress on glass, Washington, July 8-14 1962; part 2: History papers and discussions*, New York 1962, 263-282.

[8] G. Agricola, *Georgii Agricolae de Re metallica libri XII, quibus officia, instrumenta, machinae ac omnia...* apud H. Frobenium et N. Episcopium, Basileae 1556, in-fol.

[9] «*Verum sabuli vel arenæ, ex lapidibus liquescentibus confectæ, portiones duæ cum nitri vel salis fossilis, aut ex herba salsa facti una commisceantur: ad quas adjiciatur minuta magnetis particula: certe singularis illa vis nostris etiam temporib.æque ac priscis ita in se liquorem vitri trahere creditur, ut ad se ferrum allicit: tractum aut purgat, & ex viridi vel luteo candidum facit: sed magnetem postea ignis consumit*».

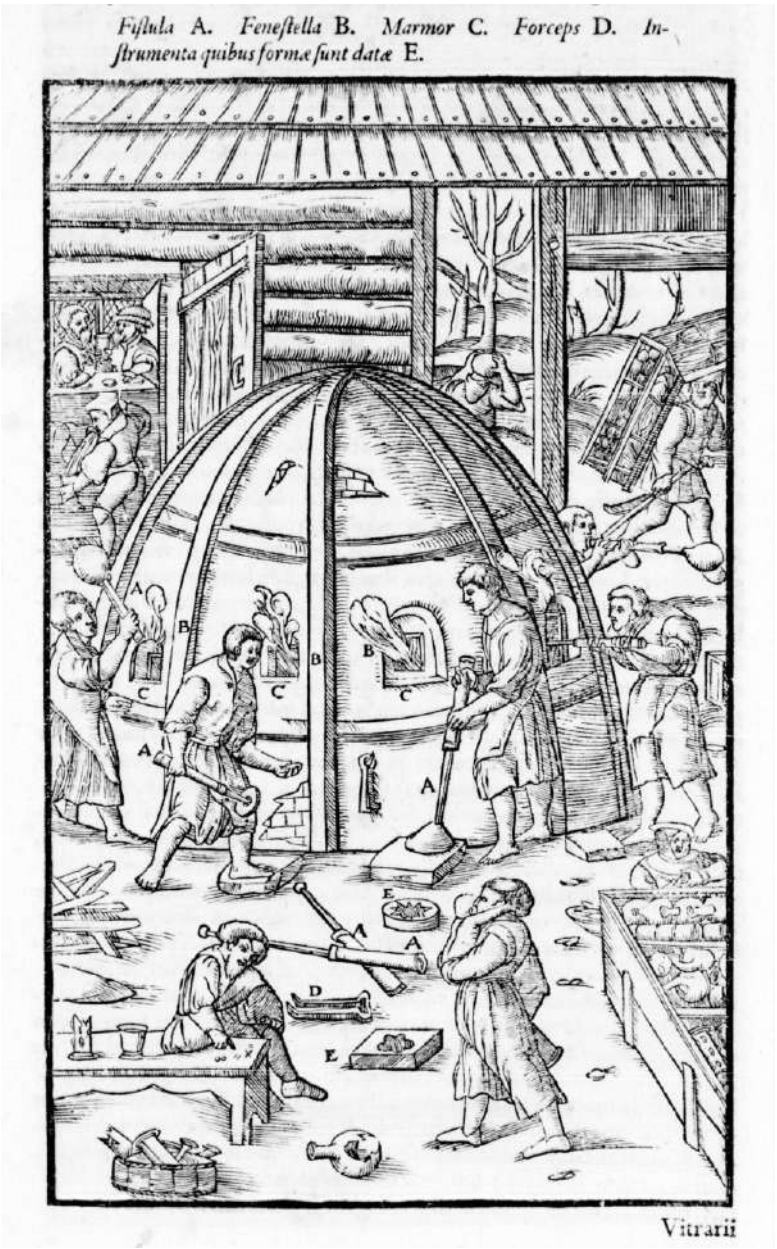

Figure 3.2. A glassmaker's furnace as described in Agricola's *De re metallica* (1556).

A: Glassblower's tube; B: furnace window; C: marble; D: pincers; E: mold tool.

Figure 3.3. Frontispiece of the book *De La Pirotechnia* (1540) by Vanoccio Biringuccio.

In Cap. 9 of Lib. 2, the author describes the use of manganese in Murano glassworks.

of Venice, where his book was published in 1540[10]. He clearly states that manganese can be used either to give glass a violet tint, which he calls «a beautiful *pavonazzo*»[11], or to remove its natural greenish colour[12]. Gerolamo Cardano mentions manganese in 1559, but incorrectly claims that it produces a blue colour[13]. Leonardo Fioravanti also mentions it in the first book of his *Specchio di scientia universale*, published in Venice in 1564, in which he describes and celebrates the art of glassmaking as practised in Murano[14]. In his *De Metallicis*, published in Rome in 1596, Andrea Caesalpino also identifies Pliny's alleged magnetite with the manganese used by glassmakers[15].

3.2 The use of manganese in Italian glassmaking

According to Luigi Zecchin[16], the earliest evidence of glassmaking in Venice is the signature of a glassmaker named Domenico, designated as a «*fiolario*», on a document dated 20 December 982. Until around 1440, Venetian glassmakers were known as «*fiolari*», after the name of the long-necked glass flask they produced called a *fiola*. To prevent fires, a decree was issued on November 1291 ordering the removal of glassworks from Venice, most of

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[10] V. Biringuccio, *De la Pirotechnia libri X, dove ampiamente si tratta non solo di ogni sorte et diversità di miniere, ma anchora quanto si ricerca intorno a la prattica di quelle cose di quel che si appartiene a l'arte de la fusione*, Curtio Navo e fratelli, Venetia 1540, in-4°, VIII-168 ff.; also see: L. Zecchin, *Vetro e vetrai di Murano*, cit., vol. 2, pp. 278-283; L. Zecchin, *Biringuccio e il vetro di Murano*, in «Giornale Economico della Camera di Commercio (Venezia)», IX, 1955, pp. 837-841.

[11] V. Biringuccio, *De la Pirotechnia*, cit., libro 2, cap. 9, about manganese: «*li maestri vetrari tegnano li lor vetri in bellissimo pavonazzo, & li maestri di vasi di terra che voglian mostrar pavonazze le lor pitture, anchor si serven di questo*» (the glass masters dye their glass a beautiful shade of purple, and earthenware vase makers who also want to create purple paintings also make use of it).

[12] Il manganese «*ha di piu anchora in se certa proprieta che mescolandone fra il vetro fuso il purga, & di verde o giallo il fa biancho*» (it also has such a property that, when mixed with melted glass, it cleans it and, from green or yellow, makes it white).

[13] G. Cardano, *Hieronymi Cardani,... De Subtilitate libri XXI...* apud G. Rouillium, Lugduni 1559, 718 pp. + index [p. 215: *Syderea, quam Manganensem Itali vocant, terra est repurgando nitro aptissima, illud tingens caeruleo colore*].

[14] L. Fioravanti, *Dello Specchio di scientia universale, dell'eccellente medico, & cirurgico Leonardo Fioravanti... libri tre...* V. Valgrisi, Venetia 1564, introductory pieces + 314 ff. [*Dell'arte de i vetri, & de suoi miracolosi effetti*: libro primo, cap. 28, ff. 66v-68v)].

[15] A. Caesalpino, *De metallicis libri tres*, Ex Typographia Aloysij Zannetti, Romae 1596, in-4°, introductory pieces + 222 pp. [pp. 152-153, 214].

[16] L. Zecchin, *Vetro e vetrai di Murano*, cit., vol. III, p. 5.

which had already been transferred to the nearby island of Murano. From this date onwards, acts and judgements relating to Venetian glassworks were primarily issued by the *Podestà* of Murano. After 1441, the glassmakers' guild was also governed by a set of rules known as the *Mariegola*.

Although Murano dominated the Italian glass market at the time, other glass manufacturing centres existed within the Most Serene Republic itself, including Vicenza and Verona[17]. Glass was also produced in Tuscany, Piegaro (near Perugia)[18], Orvieto (where glass was being made in 1360 for the famous mosaics of the cathedral)[19], and Naples[20], among other places.

As we have seen, manganese has been used as a bleaching agent since ancient times. Following its first recorded use in Venice in 1290, the word «manganese» appears frequently in Venetian documents, particularly in 15th-century glassware inventories. Examples of such references include the mentions of «*manganesium*» (12 February 1405), «*ducente libre de manganexo*» (200 pounds of manganese; 15 March 1409), «*1480 libbre di manganese*» (9 June 1410), «*unam chazolam de manganese*» (3 October 1410), «*cazzuole da manganese*» (1410), «*una pila da pestar manganexe*» (a mortar for grinding manganese; July 1439), «*manganese*» for 32 *ducati* (19 October 1446)[21], etc. Manganese was also used outside the Republic of Venice. For example, on 5 December 1360, the *Opera del Duomo* in Orvieto purchased three pounds of «*manghanese pro colorando vetrum pro musaicho*»[22]. A customs tax on manganese for glassmakers («*manghanese da bicchieri*») was in force between Bologna and Florence in 1317; manganese could also be purchased in Orciolai, near Arezzo, around 1400[23].

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[17] L. Zecchin *Vetro e vetrai di Murano*, cit., vol. II, pp. 296-302; A. Avena, *L'arte vetraria in Verona*, in «Madonna Verona», vol. V (18), 1911, pp. 112-127; L. Zecchin, *Antica arte vetraria veronese*, in «Tecnica vetraria (Milano)», vol. V (1), 1960, pp. 25-30.

[18] F. Corgna, *Le vetrerie di Piegaro dal 1250 al 1941*, Petrignani, Roma 1941, 31 pp.

[19] L. Zecchin, *Il vetro per gli antichi mosaici del duomo di Orvietto*, in «Giornale Economico della Camera di Commercio (Venezia)», vol. XV, 1961, pp. 1263-1270.

[20] L. Zecchin, *Vetrerie italiane nel quattro e cinquecento, a Napoli e altrove*, in «Tecnica vetraria (Milano)», vol. VII (3), 1962, pp. 1-4.

[21] ASV, Podestà di Murano, buste 9, 10, 16, 19 (1, cc. 144-145); L. Zecchin, *Vetro e vetrai di Murano*, cit., vol. I, pp. 3-63 [38, 39], vol. III, pp. 5-47 [27, 35], pp. 178-188 [184, 187]; L. Zecchin, *Antica arte vetraria veronese*, cit.

[22] Archivio dell'Opera del duomo di Orvieto, Cam. VI, c. 181; published in: L. Fumi, *Il duomo di Orvieto e i suoi restauri*, La Società laziale tipografico-editrice, Roma 1891, 528 pp. [p. 126].

[23] L. Frati, *Tariffa daziaria fra il Comune di Bologna e quello di Firenze (1317)*, in «Archivio

However, it is unclear whether any of the manganese oxide used in Venice or elsewhere in Italy at that time came from Praborna. Actually, most of it had another origin. For instance, a manuscript from Assisi, dating to around 1365[24], refers to an «Aragonese stone» from Catalonia that was used for bleaching glass – and was therefore most likely manganese oxide. The Most Serene Republic of Venice also sought to promote the mining of manganese in its own territories. In 1443, Iacopo Rasmini discovered a stone near Vicenza which, when ground into powder, could be used by Murano glassmakers and was probably a manganese oxide. Rasmini requested the right to extract it, pointing out that this would enable Venetian glassmakers to avoid buying the same material from «*de partibus Lombardie*», which was both insufficient in quantity and poor in quality[25]. The Council of Forty granted the requested permit for 15 years, leaving it to the Vicenza authorities to decide how much of the ore should be retained for local glassworks. On 14 February 1452, the Venetian Senate also granted a ten-year permit to exploit a manganese deposit near Vicenza – most likely the same one[26]. Finally, in 1540, Vannoccio Biringuccio reported several occurrences of manganese in his *De la Pirotechnia*[27], particularly in Italy: the mountains of Viterbo, Tuscany and the Salò region. As none of these can be attributed to Praborna, it can be deduced that this source was not widely used at the beginning of the 16th century.

From the second half of the 16th century onwards, the use of «manganese from Piedmont» in glassmaking appears to have become widespread. This appellation is found in two manuscript recipes for glassmakers, one stored in Montpellier[28] and

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Storico italiano», (ser. V) vol. XXXII, 1903, pp. 360-378 [p. 373]; G. Milanesi, *Dell'arte del vetro per musaico. Tre trattatelli dei secoli XIV e XV, ora per la prima volta pubblicati*, Gaetano Romagnoli, Bologna 1864, XIV-183 pp. [p. 1].

[24] Biblioteca comunale di Assisi, ms 642, «*Segreti per lavorare li vetri, secondo la dottrina di M[aest]ro Antonio da Pisa, singolare in tal'Arte*», circa 1365; L. Zecchin, *Vetro e vetrai di Murano*, cit., vol. I, pp. 108-113; vol. III, pp. 227-229.

[25] ASV, Maggior Consiglio, Grazie, reg. 25; L. Zecchin, *Vetro e vetrai di Murano*, cit., vol. III, pp. 184-188.

[26] ASV, Senato Terra, reg. 3, c. 18; L. Zecchin, *Vetro e vetrai di Murano*, cit., vol. I, pp. 237-241 [239], vol. III, pp. 184-188: «*Vincentino qui repprit venam lapidum manganensium qui sunt ad clarificandum vitrum, et hoc fuit non sine eius expensa et amissione temporis*».

[27] V. Biringuccio, *De la Pirotechnia*, cit.

[28] Bibliothèque de l'École de Médecine de Montpellier, ms H486, «*Ricete per far vetri colorati e smalti, havute in Murano, 1536*»; «*libretto de diversi colori*»; «*un altro libro de colori*»; «*un altro libro de colori, de metalli e di pietre*»; L. Zecchin, *Vetro e vetrai di Murano*, cit., vol. I,

the other in Venice[29], dated 1536 and 1644 respectively. Antonio Neri uses it no less than 24 times in his book *L'arte vetraria*, published in 1612[30], in which he advises against using manganese from Tuscany or Liguria, stating that «it contains a lot of iron and makes [glass] black and ugly». He recommends using manganese from Piedmont instead, describing it as «the best of all the manganese currently known in the art of glassmaking» and stating that «no other manganese is used in Murano». In 1619, Murano glassmakers working at the *Palazzo Pitti* in Florence also used manganese from Piedmont, which was imported through the port of Pisa[31].

«Piedmont manganese» undoubtedly refers to the Praborna ore, as Praborna was the only operating manganese mine in Piedmont at the time – which then included the Duchy of Aosta. A document dated 30 April 1612 and bearing the seal of Doge Leonardo Donato (Fig. 2.3) specifically refers to the manganese from Saint-Marcel as «*manganese de Piamonte*»[32], as also does a certificate dated 13 December 1612, in which Murano glassmakers state that the manganese they use comes from Saint-Marcel and declare it to be the only source of manganese in Piedmont[33]. The reputation of the «Piedmont manganese» endured until the 19th century. In a manuscript published in Siena in 1816, Adamo Mosconi affirms that «the manganese that can truly be called good is that of Piedmont. It is of exceptional quality, surpassing anything I have ever known. In fact, an ounce of this has a greater effect than six ounces of that from La Spezia»[34].

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pp. 248-276, vol. II, pp. 349-353. Before 1798, this manuscript was catalogued as Ms. 1055 in the Albani Library in Rome (C. Nicq, G. Cames, G. Velay, *Les manuscrits de l'Ecole de médecine de Montpellier*, Bibliothèque interuniversitaire de Montpellier, 1994, 24 pp.).

[29] ASV, Miscellanea di Atti diversi (manoscritti), 41b, *Ricettario Darduin*, 1644; L. Zecchin, *Vetro e vetrai di Murano*, cit., vol. III, pp. 291-311.

[30] A. Neri, *L'arte vetraria distinta in libri sette del R. P. Antonio Neri Fiorentino. Ne quali si scoprono, effetti marauigliosi, & insegnano segreti bellissimi, del vetro nel fuoco & altre cose curiose*, Nella Stamperia dé Giunti, Firenze 1612, 114+6 pp.; L. Zecchin, *Vetro e vetrai di Murano*, cit., vol. I, pp. 154-177.

[31] Archivio di Stato di Firenze, Guardaroba Medicea, filze 363 e 380; L. Zecchin, *Vetro e vetrai di Murano*, cit., vol. I, pp. 131-141.

[32] FC 165-5.

[33] «*il manganese [...] si caua nella Val di auosta nel luoco nominato S. Marcello di Riuiera in piamonte et per quanto sanno dicono non vi essere altra minera di manganese in piamonte et sauojia*» (FC 161-6).

[34] A. Mosconi, *Notizie, usi, e difetti sopra l'arte vetraja opera scritta dal dottore Adamo Mosconi su di alcuni pensieri affacciatigli dal Sig. Girolamo Mazzanti professore qualifica-*

3.3 The invention of the «cristallo veneziano» in Murano

Historians agree that a significant innovation occurred in Murano at the beginning of the Renaissance, around 1450: the production of transparent and colourless glass, the development of which is attributed to Angelo Barovier (or Berroviero) and his family[35]. This glass, known as «*cristallo veneziano*», imitated rock crystal in its transparency. It is difficult to determine precisely what this innovation consisted of, as the know-how was kept as a closely guarded secret. However, certain innovations introduced by the Baroviers at specific stages of production are well documented. These include purifying the alume catino ash (a type of sodic vegetal ash), selecting clear quartz pebbles from the Ticino river bed as a source of pure silica, accurately choosing and dosing manganese, improving the fritting process by carefully stirring and watering the *fritta* periodically. The *fritta* (molten glass) was made from a mixture of soda and crushed quartz pebbles, obtained in a *calcara* (furnace) by heating for at least five hours. The addition of manganese as a bleaching agent was essential to the fabrication of this transparent glass. In *L'arte vetraria* (1612; Fig. 3.4), Antonio Neri recommended heating this manganese, sprinkling it with vinegar – to dissolve the carbonates –, grinding it and then washing it. However, this was not a novel application of manganese, the bleaching properties of which had been recognised since ancient times. Consequently, if manganese contributed to Barovier's innovation, it was likely through its precise dosage or the use of high-quality manganese from Piedmont.

According to Luigi Zecchin, the first artefacts made of *cristallo* to leave Venice were «crystal glass vases brought from Venice», donated to the Pope around 1458[36]. Production of these objects, for which Venice held a *de facto* monopoly, boomed in the following decades. Zecchin describes the precautions taken by the Venetians to safeguard their manufacturing secrets, and

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to in tale mestiere nativo del Piegaro e domiciliato in Toscana, Dai Torchj di Onorato Porri, Siena 1816, 143 pp.; L. Zecchin, *Girolamo Mazzanti "professore vetraro"*, in «Tecnica vetraria (Milano)», vol. V (4), 1960, pp. 25-27.

[35] C.A. Levi, *L'arte del vetro in Murano nel Rinascimento e i Berroviero; note storiche*, C. Ferrari, Venezia 1895, 50 pp.; W.P. McCray, *Glassmaking in Renaissance Italy: The innovation of Venetian cristallo*, in «Member Journal of the Mineral, Metals & Materials Society (JOM)», vol. 50 (5), 1998, pp. 14-19; M. Verità, T. Toninato, *A comparative analytical investigation on the origins of the Venetian glassmaking*, in «Rivista della Stazione Sperimentale del Vetro», vol. XX (4), 1990, pp. 169-175; L. Zecchin, *Vetro e vetrai di Murano*, cit., vol. I, pp. 229-241; vol. II, pp. 199-211.

[36] L. Zecchin, *Vetro e vetrai di Murano*, cit., vol. I, p. 229: «*vasi de vitro cristallino portatis de venetiis*».

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Figure 3.4. Frontispiece of the book *L'Arte vetraria* (1612) by Antonio Neri.

recounts many instances of its success, of which we simply cite a few examples: In 1512, Isabella d'Este corresponded with Anzoleto Barovier to commission twelve lidded cups based on her own design. In 1532, Francis I, King of France, ordered «*une certaine quantité de vaisselle de verre cristallin vénitien*». Various «*lavori di cristallo*» were also commissioned for sale in the Orient[37]. The Venetian techniques and artefacts were enthusiastically described by all contemporaries, including Vannoccio Biringuccio (*De la Pirotechnia*, Venice, 1540), Georgius Agricola (*De Re Metallica*, Basel, 1556), Leonardo Fioravanti (*Dello Spechio di Scienza universale*, Venice, 1564) and Antonio Neri (*L'Arte vetraria*, Florence, 1612). Let us quote the conclusion of Book XII of Agricola's *De Re Metallica*, translated here into English: «The glassmakers produce all kinds of things, such as goblets, cups, ewers, flasks, dishes, plates, panes of glass, animals, trees and ships. I have seen these excellent and wonderful works for myself, having spent two whole years in Venice some time ago. Especially at the time of the Feast of the Ascension, they were on sale at Murano, where are the most renowned glassworks».

The invention of *cristallo* had interesting consequences for one particular field: optics. Around 1610, Galileo Galilei became personally involved in the production of Venetian *cristallo*, which was crucial for the transparency of the lenses he used in his telescopes[38] (Fig. 3.5). While teaching in Padua, he oversaw the production of these lenses in Murano. After moving to Florence in 1610, he considered engaging two Venetian glassmakers, but finally entrusted his Venetian friend Giovanfrancesco Sagredo with overseeing the lens-making process. Sagredo reported to Galileo the difficulties in obtaining homogeneous lenses during the process of «glass purification, which involves the addition of manganese. This is added after the *fritta* is made, but it does not mix easily, which can disrupt the process considerably»[39]. Among the Murano

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[37] L. Zecchin, *Vetro e vetrai di Murano*, cit., vol. I, pp. 242-245.

[38] L. Zecchin, *I cannocchiali di Galilei e gli "occhialeri" veneziani*, in «Giornale Economico della Camera di Commercio (Venezia)», vol. XI, 1957, pp. 1055-1066; L. Zecchin, *Vetro e vetrai di Murano*, cit., vol. II, pp. 255-265.

[39] «*Aspetto con sommo desiderio risposta da V.S.Ecc.ma circa quello che le scrissi del modo di purifiar il vetro, nella compositione del quale entra anco il manganese, che si mette doppo fatta la fritta et non cosi facilmente mescolandosi, può disturbar assai l'intente nostro*» (letter from Sagredo to Galileo in Firenze, Venezia, 18 agosto 1618: G. Galilei, *Le opere di Galileo Galilei: edizione nazionale sotto gli auspicii di sua maesta il re d'Italia* [pubblicata da A. Favaro, I. del Lungo, V. Cerruti, G. Govi, G.V. Schiaparelli, U. Marchesini], G. Barbera, Firenze 1890-1909, in-4, 21 voll., vol. 12, pp. 407-408 [n° 1341]). Also: «*Vi entra nel vetro il manganese, nel che mi riportai al vetraro che n'ebbe la cura, avvertito da me per ottenere la*

Figure 3.5. Objective lens and telescopes of Galileo Galilei, 1609.

«Piedmont manganese» (i.e., manganese oxide from Praborna) was used by Murano glassmakers working under the supervision of Galileo and his friend Sagredo to produce transparent and colourless lenses. The image shows two of Galileo's telescopes and a lens, preserved in the Galileo Museum in Florence. The Latin label at the bottom translates as: «On display is the optical tube invented by Galileo, with which he was the first to discern sunspots, mountains on the lunar terminator and Jupiter's moons, marking the beginning of a new era of discovery, in the year 1609» («*Tubum opticum vides Galilaeii inventum, et opus, quo solis maculas et extimos lunae montes, et Iovis satellites, et novam quasi rerum universitate primus dispexit A. MDCIX*»).

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glassmakers who produced lenses for Galileo and Sagredo was Lodovico alla Luna[40], whose name also appears in the aforementioned document of the Challant archives dated 13 December 1612, which attests to the purchase of manganese ore from Saint-Marcel[41]. Thus, in a sense, the manganese from Praborna contributed to Galileo's discoveries in astronomy, including the moons of Jupiter and the sunspots in 1610, and the phases of Venus in 1613.

Although the Barovier family and other glassmakers kept their manufacturing secrets closely guarded, a few handwritten *ricettari* containing recipes for glass and mosaic making have survived. Examples can be found in Assisi (1365)[42], Florence (ca. 1400 and 1443)[43], Bologna (ca. 1450)[44], Montpellier (1536)[45], Venice (1644)[46] and Siena (1816)[47]. Some of these recipes mention the use of manganese. Of particular interest is the Florentine manuscript dated 1443, which provides two recipes for colourless «*cristallino*» that may be similar to the contemporaneous *cristallo* produced by the Baroviers in Venice. The many ingredients specified include 150 pounds of Ticino River pebbles to be crushed and sieved finely, to which seven ounces of finely crushed, well-washed and dried manganese are added. The quantity of manganese (actually some SiO_2-bearing Mn oxide) used is 0.15 wt.%. Similarly, four recipes for colourless *cristallo* published by Mosconi in 1816 use between 0.03

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necessità omogeneità.» (letter from Sagredo to Galileo [in Firenze], Marocco, 4 agosto 1618: G. Galilei, *Le opere di Galileo Galilei*, cit., vol. 12, p. 405 [n° 1339]).

[40] Letter from Sagredo to Galileo in Bellosguardo, Venezia, 27 ottobre 1618: G. Galilei, *Le opere di Galileo Galilei*, cit., vol. 12, pp. 417-418 [n° 1352].

[41] FC 161-6 (see above).

[42] *Segreti per lavorare li vetri, secondo la dottrina di M.ro Antonio da Pisa, singolare in tal'Arte*, Biblioteca comunale di Assisi, Ms. 692; published in: G. Fratini, *Storia della basilica e del convento di S. Francesco in Assisi*, Ranieri Guasti, Prato 1882, 420 pp.

[43] Archivio di Stato di Firenze, Ms. 797; published in: G. Milanesi, *Dell'arte del vetro per musaico*, cit.

[44] *Il libro dei colori*, Biblioteca universitaria di Bologna, Ms. 2861; published in: O. Guerrini, C. Ricci, *Il libro dei colori. Segreti del secolo XV*, Romagnoli Dall'Acqua, Bologna 1887, XXVII-308 pp.

[45] Bibliothèque de l'École de Médecine de Montpellier, Ms. H486; L. Zecchin, *Vetro e vetrai di Murano*, cit., vol. I, pp. 248-276, vol. II, pp. 349-353.

[46] ASV, Miscellanea di Atti diversi (manoscritti), 41b, *Ricettario Darduin*; L. Zecchin, *Vetro e vetrai di Murano*, cit., vol. III, pp. 291-311.

[47] A. Mosconi, *Notizie, usi, e difetti sopra l'arte vetraja opera scritta dal dottore Adamo Mosconi…*, cit.

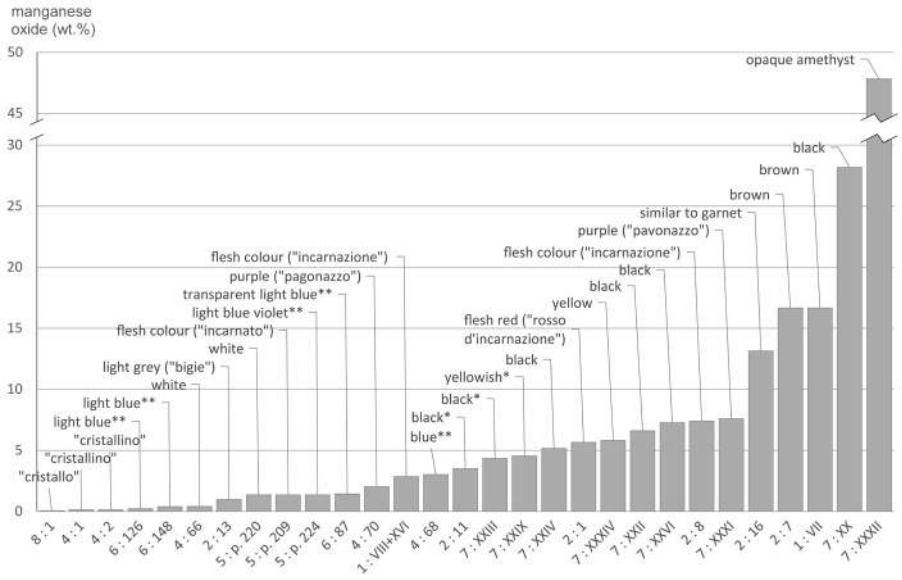

Figure 3.6. Recommended quantities of «manganese» (i.e. weight % of Mn oxide) in various glass recipes.

n : *m* is recipe *m* in «ricettario» *n*, where *n* equals 1 (Assisi, Ms. 692, ca. 1365), 2 (Florence, Ms. 797, first booklet, ca. 1400), 4 (Florence, Ms. 797, third booklet, 1443), 5 (Bologna, Ms. 2861, ca. 1450), 6 (Montpellier, Ms. H486, ca. 1536), 7 (Venice, «ricettario Darduin», 1644) or 8 (average of 4 cristallo recipe, Siena, booklet published by Mosconi, 1816).

* Indicates the presence of iron in the recipe, which blackens the glass.

** Indicates the presence of a blue colourant («zaffaro») in the recipe.

and 0.19 wt.% of «*manganese del Piemonte*», suggesting that an average of 0.10 ± 0.07 wt.% is sufficient to decolourise glass by neutralising the greenish tint caused by ferrous iron (Fe^{2+}). Other recipes use much greater quantities of «manganese» (averaging 7.27 ± 10.32 wt.%: Fig. 3.6), which results in flesh-coloured («*incarnato*»), purple («*pavonazzo*»), or violet tints. Logically, the greater the quantity of manganese, the more pronounced the tint; for the highest concentrations, the glass even becomes opaque (Fig. 3.6). However, since manganese was frequently mixed with other colourants, the resulting colour could vary considerably. The quantities reported by these recipes are comparable to Mn analyses, expressed as MnO wt.%, of coloured ancient glasses[48].

3.4 The Manufacture royale des Glaces in Saint-Gobain

Another Venetian artefact produced with *cristallo* was mirrors. In May 1507, the Dal Gallo brothers applied for a privilege to exploit their «secret for making mirrors of true *cristallin*». The glassmakers produced large, hollow glass balls, which they cut into pieces of various sizes and arranged on iron plates. They then returned these to the furnace until the glass lay flat on the plate, after which they left it to cool. While some imperfections in window panes were tolerated, mirrors had to be made of perfect glass plates. The glass had to be as transparent as possible, of course, and great care was taken over the quality and dosage of manganese.

France was an important customer of Venice for various manufactured goods, particularly these precious – and expensive – mirrors. In 1664, Jean-Baptiste Colbert became *Surintendant des bâtiments, arts et manufactures* and devised a new economic plan that included producing glass in France[49]. He

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[48] E.V. Sayre, *The intentional use of antimony and manganese in ancient glasses*, in F.R. Matson, G.E. Rindone (Eds.), *Advances in glass technology: technical papers of the 6. International Congress on glass, Washington, July 8-14 1962; part 2: History papers and discussions*, New York 1962, pp. 263-282; P. Costagliola, G. Baldi, C. Cipriani, E. Pecchioni, A. Buccianti, *Mineralogical and chemical characterisation of the Medicean glass mosaic tesserae and mortars of the Grotta del Buontalenti, Giardino di Boboli, Florence, Italy*, in «Journal of Cultural Heritage», vol. 1 (3), 2000, pp. 287-299.

[49] L. Zecchin, *Colbert e gli specchi veneziani,* in «Giornale Economico della Camera di Commercio (Venezia)», vol. III, 1949, pp. 201-206, 253-258: vol. XVI, 1962, pp. 1278-1285; vol. XVII, 1963, pp. 46-53, 405-410, 998-1004; vol. XVIII, 1964, pp. 364-368; L. Zecchin, *Vetro e vetrai di Murano*, cit., vol. I, pp. 299-308; E. Frémy, *Histoire de la Manufacture royale des glaces de France au XVII^e^ et au XVIII^e^ siècle*, Plon-Nourrit et Cie, Paris 1909, XII-445 pp.; A. Cochin, *La Manufacture des glaces de Saint-Gobain de 1665 à 1865*, C. Douniol, Paris 1865, 192 pp.

approached Pierre de Bonzi, the Italian-born Bishop of Béziers and French ambassador to Venice, to recruit skilled glassmakers willing to travel to France to produce mirrors. The bishop replied that there were very few such workers, as only two workshops in Murano produced mirror glass. Furthermore, if these glassmakers were to work outside Murano, their property would be confiscated and they and their families would be banished from the Republic of Venice.

Colbert did not give up. Instead, he formed a group of financiers to support his project and appointed Nicolas de Noyer, a tax collector from Orléans, to lead it. He purchased buildings in the Parisian suburb of Saint-Antoine, with the intention of converting them into workshops and providing housing for the workers. Meanwhile, Paolo Mazzolao, a Murano glassmaker living in Rouen, was commissioned to prepare the factory and build the furnaces, despite not being an expert in mirror production. Colbert also tasked Giovanni Castellano, the owner of a glassworks in Nevers, with recruiting glassmakers in Venice. On 12 June 1665, Castellano sent to Venice his son-in-law, Marco Bormiolo – the ancestor of the family who founded the Bormioli glassworks. Some workers left their families and travelled to Paris, where they arrived after numerous misadventures.

In August 1665, Alvise Sagredo, the Venetian ambassador in Paris – and nephew of Giovanfrancesco Sagredo, friend and collaborator of Galileo, as previously mentioned – reported to the Republic of Venice the arrival of the workers. The State Inquisitors – an institution of the Venetian Republic responsible for addressing threats to state security – instructed Sagredo to inform the workers that they would be granted a safe conduct pass valid for six months if they returned to Venice. The workers did not accept. Consequently, a factory was set up in the *Faubourg Saint-Antoine* near Paris and De Noyer's company was granted a 20-year monopoly on the production of mirrors and other glass objects in Paris, and took the name *Manufacture royale des glaces à miroirs*. The workers who remained in Paris for about two years received an annual pension from Louis XIV, King of France. In June 1667, the glassmakers returned to Venice after succumbing to a skilful combination of persuasive speeches, generous offers and violent incidents (including two suspicious deaths!), all orchestrated by Marco Antonio Giustiniani, the new ambassador of the Republic of Venice[50] – which was not as serene as usual. However, De Noyer's glassworks continued to operate after these departures. Around

[50] E. Frémy, *Histoire de la Manufacture royale des glaces de France au XVII^e^ et au XVIII^e^ siècle*, cit.

1670, the factory incorporated the one in Tourlaville, Normandy, where the secret of glass decolourisation had also been unravelled. This enabled the latter to supply the glass for the Hall of Mirrors at the Palace of Versailles between 1682 and 1684.

At the end of the 20-year monopoly in 1685, a rival company established a factory in Paris and introduced a new technique that involved the casting of glass instead of the traditional blowing method. After a difficult start, the managers decided in 1693 to relocate their furnaces from Paris to Saint-Gobain in Picardy. This location offered access to abundant forests for wood and proximity to the Oise River for shipping raw materials and finished products. Louis XIV then ordered the two companies to merge to form the *Manufacture royale des glaces de France*, which continues to operate under the name «Saint-Gobain» to this day.

The spread of the glass industry from Venice to France and other European countries at the end of the 17th century coincided with the development of the manganese trade from Praborna across the Alpine passes[51]. However, competing deposits were discovered during the 18th century. In 1740, Johann Heinrich Pott, although acknowledging the primacy of Piedmont manganese, listed a dozen deposits mined in Europe, including sites in Somerset, in Saxony, near the Harz, in Friuli and Tuscany[52]. Furthermore, the manganese trade declined in the 19th century due to the introduction of more efficient bleaching agents. Lead oxide was used in the production of Bohemian crystal and, at an even higher concentration, in English crystal. Murano crystal continued to use manganese for a long time to produce glass that was more rigid when cold, meaning it had to be processed while still hot. Today, the company Barovier & Toso still uses manganese, in the form of approximately 375 ppm of $Mn^{4+}O_2$, in the composition of the glass known as *Cristallo di Murano*. However, its production has declined considerably over the last two centuries. Since the high silica content of the manganese ore from Praborna made it unsuitable for other applications, the closure of the mine was inescapable.

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[51] See Section 2.3.

[52] J.H. Pott, *Examen chymicum magnesiae vitriariorum, Germanis Braunstein*, in «Miscellanea berolinensia ad incrementum scientiarum ex scriptis Societati regiae scientiarum», vol. VI, 1740, pp. 40-53.

SECOND PART

A PARADISE FOR MINERALOGISTS (18TH TO 21ST CENTURIES)

The ancient Praborna mine is not only the source of Piedmont manganese, which glassmakers have used since the 15th century. It is also the type locality for several rare manganiferous minerals, including piemontite, violan (a semiprecious violet-blue Mn-bearing clinopyroxene), alurgite (the Mn-bearing variety of muscovite), roméite (a complex oxide of Sb, Mn, Fe), greenovite (a variety of titanite) and strontiomelane. Many other manganese minerals have also been observed, including braunite, garnets (spessartine, blythite and calderite), androsite, various Mn-bearing clinopyroxenes (augite, jadeite and chloromelanite), rhodonite, K-F-Mn richterite, hollandite, vanadates, rhodochrosite, and many others.

In this second part, we first explore how scientists have discovered and perceived this natural heritage since the 18th century. Next, we summarise the current geological and petrological knowledge relating to Praborna. Finally, we compile a mineralogical inventory, inevitably incomplete, of the deposit.

Chapter 4

An open-air museum of mineralogy since the 18th century

The ancient Praborna mine has long been highly prized by scientists and collectors alike. Indeed, it is regarded as a kind of open-air museum of minerals. Here, we explore the history of this fascination, from the 18th century to the present day, while the mine continues to provide mineralogists and crystallographers with fine specimens of rare minerals.

4.1 Praborna and the first mineralogists of the 18th century

The first «geognosic» studies of the Saint-Marcel region were conducted in the 1780s by Spirito Benedetto Nicolis de Robilant, Inspector General of Mines for the Piedmont-Sardinia Kingdom[1]. His studies reveal very simple geological concepts inspired by the Neptunist theory that prevailed at that time in Freiberg (Saxony), where Robilant had stayed around 1750[2]. Robilant considered that lithological formations were arranged in superimposed and tilted layers, as can be seen clearly in his 1788 geological cross-section (fig. 2 in Fig. 4.1). The «pyrite layers with garnet» were mined for copper at Champ-de-Praz, Fénis, and Servette (Saint-Marcel). At a higher stratigraphic level, a «manganese layer» corresponded to the Praborna mine.

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https://doi.org/10.14672/QUAD2026-47-5

[1] S.B. Nicolis de Robilant, *Essai géographique suivi d'une topographie souterraine minéralogique et d'une docimasie des Etats du Roi de Sardaigne en terre ferme*, in «Mémoires de l'Académie royale des Sciences [de Turin]», 1784-1785, 1786, pp. 191-304; S.B. Nicolis de Robilant, *Description particulière du Duché d'Aoste, suivi d'essai sur deux minières des anciens romains, et d'un supplément à la théorie des montagnes et des mines*, in «Mémoires de l'Académie royale des Sciences [de Turin]», 1786-1787, 1788, pp. 245-274 + pl. VII-IX.

[2] [A. Miédan], C*enni biografici riguardanti il cavaliere Nicolis di Robilant. Notice biographique sur le chevalier Nicolis de Robilant*, in «Repertorio delle Miniere ossia Raccolta di Regie Patenti, Regolamenti, Memorie e Notizie sopra le Sostanze Minerali degli Stati di S. M. il Re di Sardegna. Répertoire des mines ou Recueil de Lettres-Patentes, Réglemens, Mémoires et Notices sur les Substances Minérales des États de S. M. le Roi de Sardaigne», t. II (1825), 1826, pp. 170-183.

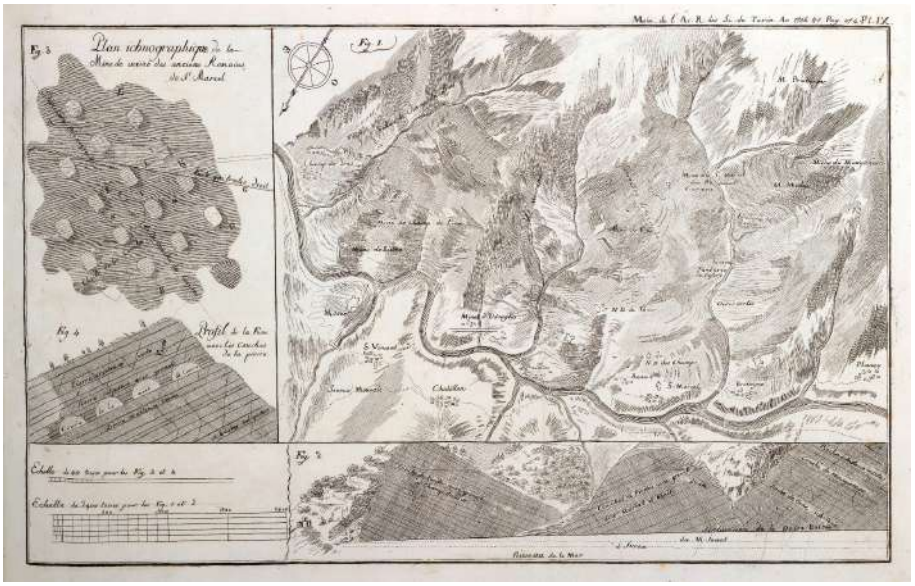

Figure 4.1. Map and geological profile of the Saint-Marcel mines by Nicolis de Robilant (1788).

Spirito Benedetto Nicolis de Robilant, Inspector General of the Piedmont-Sardinia mines, published in 1788 a *Description particulière du Duché d'Aoste, suivi d'essai sur deux minières des anciens romains…*, in «Mémoires de l'Académie royale des Sciences de Turin», années 1786-1787, t. 3, Torino 1788, pp. 245-274. Plate IX of this memoir shows a map of the Saint-Marcel region («Fig. 1» above), on which can be seen the «*Mine de Manganèse*» (i.e. Praborna) and various copper mines (Champ de Praz, Fénis, Saint-Marcel [Servette]). Figure 2 shows a geological profile with tilted layers, including various «*couches de pirites avec grenats*» and one «*couche de manganese*». Figures 3 and 4 are, respectively, a map and a profile of the ancient Servette copper mine, which allegedly dates back to Roman times.

Figure 4.2. Horace-Bénédict de Saussure.

On 11 August 1792, the Alpine geologist Horace-Bénédict de Saussure visited the Praborna mine, of which he provided a description in his book *Voyages dans les Alpes* (from a portrait painted by Jens Juel in 1778, Geneva Library).

At the same period, the Praborna deposit began to attract the interest of a few mineral collectors. In 1775, Cardinal Infante Don Luis Antonio de Borbón y Farnesio (1727-1785), son of Philip V of Spain and Elisabeth Farnese, obtained from the Duke of Savoy a sample of «manganese, excellent for glassmaking, compact with small flakes, in a steatite and talc matrix, from Saint-Marcel in the Duchy of Aosta»[3], which he added to his *Gabinete de Historia Natural* in his palace in Boadilla del Monte, near Madrid.

Joseph-Dominique Davise, son of Jean-Baptiste – the owner of the Praborna mine –, amassed an important collection of minerals from the Aosta Valley, particularly from Saint-Marcel, which he displayed at his home in Aosta. Unfortunately, the collection was not preserved, but it was briefly described by several naturalists, including Franz Samuel Wild in 1787[4] and Deodat Gratet de Dolomieu in 1797[5].

The Swiss canon Laurent-Joseph Murith (1742-1816) assembled a collection of rocks and minerals from Valais and the Duchy of Aosta at the Hospice of the Great St Bernard Pass[6]. This included eight samples of «*manganèse*» (i.e., braunite) from the Duchy of Aosta, associated with various minerals such as «*schörl violet*»[7] (piemontite or violan), «*spath rouge*» (rhodochrosite?) and «*amianthe*» (possibly a fibrous amphibole)[8]. Three of these samples are still preserved in the hospice museum and bear labels written in Murith's handwriting: n° M414: «*Manganèse avec une nouvelle substance violette*»; n° M415: «*Epidote manganesiée de St Marcel*»; and n° M651: «*Grenat Hya-*

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[3] *Catalogo dei fossili, e minerali dei Ragj Stati, componenti la raccolta mandata da S.M. a D. Luigi Infante di Spagna* (AST SC, Materie economiche, seconda addizione, Miniere, Mazzo 2, Fascicolo 23).

[4] F.S. Wild, *Drittier Brief von Herrn Berghauptmann Wild, in Ber [den 19. August 1787]*, in «Magazin für die Naturkunde Helvetiens [Albrecht Hoepfners Magazin]», II Band, 1788, pp. 278-286 [p. 282].

[5] D. Gratet de Dolomieu, *V[oyag]e de l'an 5 aux Alpes, 1797*, Archives de l'Académie des Sciences de Paris, Ms 4J6.

[6] S. Ansermet, *Laurent-Joseph Murith, premier minéralogiste valaisan*, in L.J. Murith, P. Rouyer (Eds.), *Le guide du botaniste qui voyage dans le Valais*, Les éditions du Grand Saint Bernard 2016, pp. 193-206. We would like to thank Stefan Ansermet for the information provided on the Murith collection.

[7] Prior to the introduction of terms such as «pyroxene» and «amphibole» (by Haüy in 1801), the term «schorl» was used to denote any coloured, prismatic silicate.

[8] End of the 18th century, *Collection d'histoire naturelle du Valais avec divers morceaux étrangers. Collection Murith-Saussure*. Archives du Grand Saint Bernard, ms AGSB 5256/a [p. 15].

Figure 4.3. Some of the specimens collected by Horace-Bénédict de Saussure in the Saint-Marcel Valley on 20 August 1792 and now stored at the Natural History Museum in Geneva.

a: Chloritoid-bearing micaschist, where the chloritoid is incorrectly described as mirror-like hematite; b: «*schorl bleuâtre*» (actually glaucophanite); c: «manganèse rouge» (piemontite) forming prisms in a quartz matrix; d: sample showing «*manganèse noire*» (braunite, in black), a violet mineral (probably violan) and greyish fibrous crusts (possibly pyrolusite, in the bottom left corner); e: dark quartzite with veinlets rich in a copper-coloured mica (alurgite); f: «*gneiss with a green mica*» (likely, fuchsite or mariposite). Specimens a and b were collected between Servette and Praborna, whereas samples c to f come from Praborna, with f possibly originating from the Cr-rich emerald green level of Praborna.

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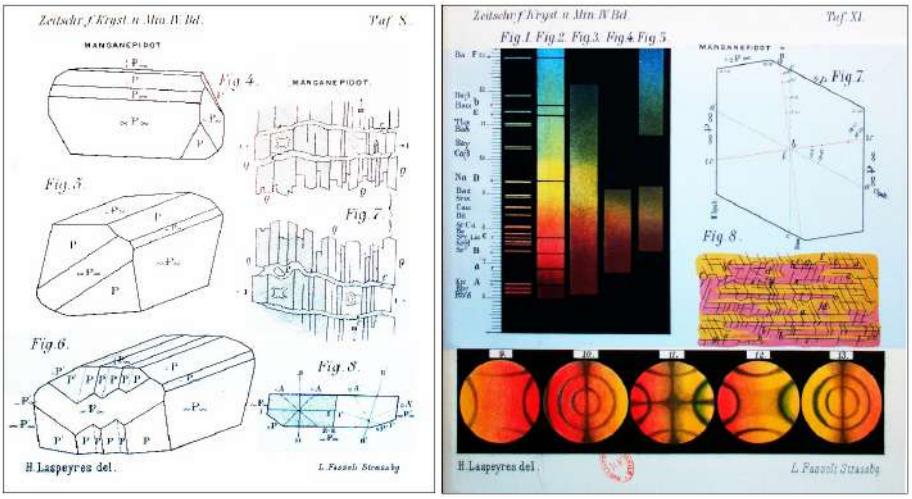

Figure 4.4. Crystal forms and optical properties of the piemontite from Saint-Marcel, as depicted by Hugo Laspeyres in 1879.

Taf. X (left). Fig. 4: crystal with the clinopinacoid facing the viewer; Fig. 5: crystal with the orthopinacoid facing the viewer; Fig. 6: polysynthetic twins (P and P' alternating), with the orthopinacoid facing the viewer; Fig. 7: thin section of such a polysynthetic twinned crystal of piemontite embedded in quartz (Q) and interspersed with calcite (C); the surface of the individual in grey is normal to the second bisector; Fig. 8: ideal cross-section of the twin through the plane of the optical axes (oA) and bisectors (I and II).

Taf. XI (right). Fig. 3: absorption spectrum of manganese epidote for a polarising light beam whose vibrations are parallel to the greatest elasticity axis α; Fig. 7: projection of the crystallographic and optical axes of piemontite onto the plane of symmetry; Fig. 8: interference image of a thin section; Figs. 9-13: interference images under a converging light beam of various piemontite thin sections, (9) normal to the second bisector, (10) normal to the optical axis close to (001), (11, 12) normal to the first bisector, (13) normal to the optical axis close to (100).

H. Laspeyres, *Die kristallographischen und optischen Eigenschaffen des Manganepidot (Piemontit)*, in «Zeitschrift für Kristallographie und Mineralogie», IV, 1879, pp. 435-468 + Taf. X-XII.

cinthe de prazborgne». The naturalist Michel Adanson (1727-1808) also possessed a piemontite specimen labelled «*Manganaise de St. Marcel du Duché d'Aoste*» in his mineral collection[9].

In September 1791, the French scholar Louis Benjamin Fleuriau de Bellevue included Praborna in the itinerary of his Grand Tour. There, he observed «a quartz of a light violet red» (possibly violan), «a mica of a bright violet red» (certainly alurgite) and some «reddish schorl in striated masses and sometimes in quadrilateral needles in quartz» (our piemontite)[10]. He gave two specimens of this substance to the renowned Genevan geologist Horace-Bénédict de Saussure, who described it under the name «*manganèse rouge*»[11].

Horace-Bénédict de Saussure also made the trip to Saint-Marcel and Praborna, which he visited on 20 August 1792. In his book *Voyages dans les Alpes*[12], he briefly describes the mine and the structure of the layers, and provides a short account of the minerals he observed. He emphasises the presence of «*manganèse rouge*» (i.e., piemontite), «*manganèse noire*» (i.e., braunite), and a fibrous white mineral in the gangue (most likely amphibole). De Saussure left a collection of rocks, which are still preserved at the Natural History Museum in Geneva. A dozen specimens come from Praborna (Fig. 4.3). Alongside samples of piemontite (Fig. 4.3c), braunite, and alurgite (Fig. 4.3e), there is a specimen that appears to contain violan, a mineral that De Saussure did not mention (Fig. 4.3d). As he also visited the Servette copper mine, which is located 2 km north of Praborna, the samples from Saint-Marcel also include garnet micaschists, «*schorl bleuâtre*» (glaucophanite: Fig. 4.3b), chalcopyrite and garnet crystals, as well as two samples of «*hématite spéculaire*» (mirror-like hematite: Fig. 4.3a), which are actually spectacular chloritoid crystals, later named «sismondine» by Bertrand de Lom.

4.2 Manganese: a new chemical element

While geology was still in its infancy, significant progress was made in chemistry concerning the true nature of manganese. For 18th-century scientists

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[9] É. Asselborn, *Michel Adanson and his mineral collection*, in «Mineralogical Record», 2026 [under press]. We would like to thank Éric Asselborn for the information provided on the Davise and Adanson collections.

[10] C. Moreau, *Le grand voyage de Louis Benjamin Fleuriau de Bellevue (octobre 1788 à février 1793)*, Les Indes Savantes 2024, 355 pp. [pp. 278-279].

[11] H.-B. de Saussure, *Voyages dans les Alpes*, cit., vol. 4, p. 78 (§1896).

[12] H.-B. de Saussure, *Voyages dans les Alpes*, cit., vol. 4, pp. 456-458 (§2294).

and glassmakers, manganese was a homogeneous black mineral containing impurities such as quartz. In the second half of the century, attempts were made to determine its composition by trying to break it down into simpler constituents. However, the results were contradictory and confusing[13]. Its density suggested the presence of metals, and many believed that it contained iron, as did Buffon for example[14]. In 1772, Balthasar-Georges Sage, a member of the Paris Academy of Sciences, proposed the following composition for manganese from Piedmont (and therefore from Praborna)[15]: 10% «marine acid», 70% zinc, 10% iron, and 10% cobalt. When mixed with molten glass, it would absorb the «phlogiston» contained within the latter, which could explain the changes in colour. It is worth recalling that, according to the theories in force at the time, phlogiston was a form of fire fixed within matter that escaped during combustion. The more a substance contained it, the better it burned.

The emergence of modern chemistry, of course, revolutionised these concepts. In 1774, the Swedish chemist Johan Gottlieb Gahn of Uppsala succeeded in isolating a simple metallic element from the «manganese» used by glassmakers. In 1780, his colleague Torbern Bergman theorised that the manganese used by glassmakers might be a compound of this new metal, which he suggested naming «*magnesium*» after the Latin term «*magnesia nigra*» given to the ore[16]. However, in his Lavoisier-inspired nomenclature of chemical elements in 1785, the French chemist Louis-Bernard Guyton de Morveau called it «*manganèse*» instead. This altered the meaning of the term, as the «manganese» used by glassmakers was an oxide of Guyton de Morveau's manganese. Whereas «manganese» in the sense of the glassmakers absorbed phlogiston from the glass it was incorporated into, it then became the glass that absorbed oxygen from the manganese oxide.

In 1788, Carlo Antonio Galeani Napione attempted to apply these new chemical concepts to the minerals of Praborna. He presented a chemical analysis of «red manganese» (now known as piemontite) to the Turin Academy of Sciences[17].

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[13] E.g., A.-D. Fougeroux de Bondaroy, *De la manganèse de Piémont, Mss.B.D87, 1780*, Archives of the American Philosophical Society, Philadelphia, USA.

[14] G.-L. Leclerc comte de Buffon, *De la Manganèse*, in *Histoire naturelle des minéraux*, Impr. royale, Paris 1783-1788, t. III, pp. 385-392.

[15] B.-G. Sage, *Élémens de mineralogie docimastique*, Delormel, Paris 1772, XXIV-276 pp. [p. 177].

[16] T. Bergman, *Opuscula physica et chemica... litteris direct. J. Edman*, Upsaliae 1780, vol. II, pp. 201-203.

[17] C.A. Napione, *Analyse de la mine de manganèse rouge du Piémont par M. le chevalier*

He obtained the following result, which, incidentally, is clearly erroneous: silica, 26.14%; lime, 23.00%; alumina, 0.81%; «manganese» (plus iron), 45.95%; water, 3.00%; total, 98.84%; loss, 1.21%. It is noteworthy that he still used the term «manganese» in its older sense, actually referring to manganese oxide.

In 1800, Louis Cordier and Louis-Antoine Beaunier conducted the first chemical analysis of «oxidised manganese from Piedmont», thereby analysing the Praborna ore[18]. It became clear that the new chemical element could combine with other elements to form silicates, oxides and carbonates, which could have very different appearances and properties.

4.3 A laboratory for mineralogists (19th century)

The chemical scientific revolution paved the way for the study of Praborna's minerals. In addition to chemical analyses, their crystalline forms were studied, notably using the goniometer. Later, tourmaline tongs and then the polarising microscope were employed to determine their optical properties. Thus, the 19th century saw significant progress in mineralogical studies at Praborna. This led to the characterisation of marcelline (later named braunite), piemontite (Fig. 4.4), various species of garnet and pyroxene, roméite, greenovite, alurgite, and many other mineral species and varieties, several of which have Praborna as their type locality. These discoveries are presented in Chapter 6, which is dedicated to mineralogy, so they will not be detailed here. Prominent mineralogists who participated in these studies include: Haüy, Breithaupt, Dufrénoy, Damour, Des Cloizeaux, Kenngott, Laspeyres, D'Achiardi, vom Rath, Penfield, Millosevich and Colomba. Let us focus on two relatively unknown figures who nonetheless played an important role in Prabornian mineralogy: Jean-Pierre Bertrand de Lom and Fausta Balzac.

Jean-Pierre Bertrand was born on 2 Ventôse of Year VII (1 March 1799) in Le Puy-en-Velay, located in the Massif Central region of France[19]. On 5 May

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Napion, in «Mémoires de l'Académie royale des sciences [de Turin]», vol. IX (1788-1789), 1790, pp. 303-308.

[18] L. Cordier, L.-A. Beaunier, *Rapport à la Conférence des Mines, sur les manganèses, oxidés, susceptibles d'être employés dans les procédés des arts*, in «Journal des Mines», vol. 10 (n° LVIII, Messidor), 1800-1801 [an IX], pp. 763-788 [p. 775].

[19] D. Barrier-Millet, *Un savant vellave méconnu du 19e siècle: Bertrand de Lom (1799-1878), minéralogiste et géologue*, in «Per Lous Chamis, la mémoire du Velay», 1987-1988, vol. 51, pp. 15-23; vol. 52, pp. 74-81; F.H. Forestier, *Jean-Pierre Bertrand de Lom (1799-1878), prospecteur-mineralogiste vellave, et son œuvre gemmologique*, in «Cahiers de la Haute-Loire», 1995, pp. 259-324.

1824, he married Anne-Marie de Lom and adopted the name Jean-Pierre Bertrand de Lom, adding her name to his own. Initially, he worked in partnership with his brother-in-law as a lace merchant in Le Puy. However, his true passion was mineralogy, which he pursued as a self-taught amateur. He moved to Paris, where he attended courses at La Sorbonne, the École des Mines and the Collège de France. In 1832, he travelled to Piedmont, where he worked for the mining administration of the Kingdom of Piedmont-Sardinia. For about ten years, he studied mineral deposits there, particularly those of Traversella and Saint-Marcel. According to the *Journal de la Haute-Loire*[20], this tireless pioneer would disappear into the mountains each year, surviving on polenta for three or four months. He would then reappear, carrying crates full of minerals that he had extracted from the sites he had studied. In his 1840 handwritten reports[21] to Charles-Marie-Joseph Despine, Inspector General of Mines for the Piedmont-Sardinia Kingdom, Bertrand de Lom described the minerals of the Praborna mine, in particular «marcelline» (braunite), «manganese-bearing yellow garnet» (spessartite), «manganese-bearing epidote» (piemontite), tremolite and «purple mica» (alurgite). He also identified three new mineral species and proposed naming them albertine, emmanueline and philibertine in honour of King Carlo Alberto and the princes of the House of Savoy. However, as reported in 1841 by Élie de Beaumont and Dufrénoy, «Mr De Lom, an intelligent and active collector, lacks the crystallographic and chemical knowledge necessary to determine species and describe his discoveries. He is therefore obliged to abandon this task to more learned hands»[22]. Consequently, he entrusted the study of his findings to the Parisian mineralogists Armand Dufrénoy, Alfred Des Cloizeaux and Alexis Damour. Dufrénoy and Damour eventually identified two new mineral species among the samples brought back by Bertrand de Lom: greenovite[23] and

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[20] E. Moullade, *Travaux de M. Bertrand de Lom*, in «La Haute-Loire», 66ème année, mardi 6 mars 1877 (n° 27), jeudi 15 mars 1877 (n° 31, pp. 2-3).

[21] «Description minéralogique et géognostique du dépot de minerai de manganèse du haut de la combe de St. Marcel, vallée d'Aosta, Piémont» (7 June 1840; FD 11 J 423) and 3 letters from Bertrand de Lom to Despine (24 June, 15 September and 2 october 1840; FD 11 J 423).

[22] L. Élie de Beaumont, A. Dufrénoy, *Rapport sur un Mémoire de M. Damour ayant pour titre: Notice sur la Roméine, nouvelle espèce minérale*, in «Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences [de Paris]», vol. XIII, 1841, pp. 859-860.

[23] A. Dufrénoy, *Description de la Greenovite*, in «Annales des Mines», (3ème sér.) vol. 17, 1840, pp. 529-545 + pl. X; A. Dufrénoy, *Description de la Greenovite*, in «Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences [de Paris]», vol. 11, 1840, p. 234. Today, greenovite is considered a variety of titanite.

roméine[24]. Perhaps reluctant to honour foreign princes, they preferred to name them after the English geologist Greenough and the French mineralogist Romé de L'Isle. Notably, however, they neglected to associate Jean-Pierre Bertrand de Lom to the publication of their results despite acknowledging his contribution to their work.

In the Saint-Marcel valley, near the Servette copper mine, Bertrand de Lom also observed a mineral that he named «sismondine»[25] (actually a variety of chloritoid), and a copper-rich turquoise precipitate formed in the *Eve Verda* stream bed, which he called «chalcogelide»[26]. In 1843, he reported a new lens of manganese ore at Praborna, approximately fifteen metres from the active mine, which he proudly announced in the periodicals *Écho du monde savant* and *Feuille d'annonces d'Aoste*[27]. Finally, in his 1844 memoir[28], he reviewed the 24 minerals that he observed at Praborna, including the rare species thallite, «*mica vert émeraude*» (fuchsite), «*ouwarowite*» and gold, the discovery of which at Praborna is generally attributed to more recent authors. He also noted the occurrence of native gold associated with «nigrine» (ilmenite) in the «talcose rocks» (micaschists) of Saint-Marcel, which led him, together with Vittorio Seyssel, Marquis d'Aix (1804-1856), to apply in 1850 for a gold concession in the territories of Saint-Marcel and Brissogne, but this proved

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[24] A. Damour, *Sur la Roméine, nouvelle espèce minérale*, in «Écho du Monde savant», 8ème année, 1841, n° 661, 1er septembre 1841, p. 506; n° 676, 27 octobre 1841, pp. 628-629; A. Damour, *Sur la roméine, nouvelle espèce minérale, de Saint-Marcel en Piémont*, in «Annales des Mines», (3ème sér.) vol. 20, 1841, pp. 247-254.

[25] A. Delesse, *Analyse de quelques minéraux; Sismondine (nouveau minéral)*, in «Annales de Chimie et de Physique», (3ème sér.) vol. 9, 1843, pp. 388-394; Bertrand de Lom also collected both villarsite, now identified as an altered peridot, and faujasite in Traversella and Kaiserstuhl, respectively.

[26] S. Tumiati, G. Godard, N. Masciocchi, S. Martin, D. Monticelli, *Environmental factors controlling the precipitation of Cu-bearing hydrotalcite-like compounds from mine waters. The case of the "Eve verda" spring (Aosta Valley, Italy)*, in «European Journal of Mineralogy», vol. 20, 2008, pp. 73-94.

[27] J.P. Bertrand de Lom, *Description géologique et minéralogique d'un nouveau dépôt de manganèse récemment découvert dans les états de Sardaigne*, in «Écho du Monde savant», 10ème année (n° 5, 16 juillet 1843), col. 104-107; idem in «Feuille d'Annonces d'Aoste», 15 octobre 1843, pp. 1-3.

[28] J.P. Bertrand de Lom, *Description minéralogique et géognostique de la mine de manganèse de Saint-Marcel en Piémont, et de quelques faits de même genre de la vallée où gît cette mine*, in «Écho du Monde savant», 11ème année (n° 21, 17 mars 1844), col. 487-495.

unproductive[29]. Short of money, he sold in May 1857 two fine samples of twinned greenovite and braunite to Quintino Sella (who would later become Italy's Minister of Finance) for 500 and 140 Francs respectively[30].

Despite lacking recognition from the academic world, Jean-Pierre Bertrand de Lom continued his mineralogical searches, particularly in his native Velay region. There, he identified occurrences of corundum and sapphire brought to the surface by Pliocene basalts. He died in Le Puy-en-Velay in 1878. Although the municipality attempted to acquire his mineralogical collections, it is unclear whether the couple of piemontite specimens held by the Crozatier Museum in Le Puy-en-Velay actually came from him. The novelist Aimé Giron (1836-1907) was inspired by Bertrand de Lom, whom he knew in Le Puy-en-Velay, when creating the characters Frangeat and Mathieu Le Long for his novels *Le Vieux ramasseur de pierres* and *Une lieue de dentelle*[31] (Fig. 4.5).

Another endearing figure in the mineralogy of Praborna was Fausta Balzac, one of the first Italian female mineralogists. On 23 June 1915, she obtained a degree in Natural Sciences from the University of Turin, achieving a grade of 110/110 *cum laude*[32]. Her first studies focused on the use of the plant *Artemisia absinthium* in the production of vermouth and genepi[33]. From 1915 to 1920, she became an *assistente volontaria* at the Mineralogy Museum of the University of Turin, under the direction of Professor Ferruccio Zambonini. The position of *assistente universitario volontario* was unpaid, but enabled to

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[29] *Demande de concession pour or de St-Marcel et Brissogne*, AST SR, Ministero delle finanze, Intendenza di Ivrea, Categoria VI, Miniere, mazzo 866 (30 July 1850); *Richiesta di concessione per una miniera d'oro (St-Marcel e Brissogne), presentata da Seyssel d'Aix e Bertrand de Lom*, FD 11 J 738 (21 May 1854); *Planimetria della miniera orifera esistente nelle comuni di S. Marcello, Brissogne e Cogne*, AST SC, Distretto Minerario del Piemonte, Terzo versamento, Piani di miniera, mazzo 5, fascicolo 25 (17 June 1856); *Plan démonstratif des localités situées sur le territoire de St Marcel où existent la mine de cuivre exploitée par la société l'Exploratrice, la mine de manganèse exploitée par les frères Bordon et la mine d'or, schiste aurifère, de Bertrand de L'Orm [sic] et comte Seyssel, avec la délimitation des trois concessions*, AST SC, Distretto Minerario del Piemonte, Terzo versamento, Piani di miniera, mazzo 15, fascicolo 40 (5 May 1860).

[30] E. Moullade, *Travaux de M. Bertrand de Lom*, cit.

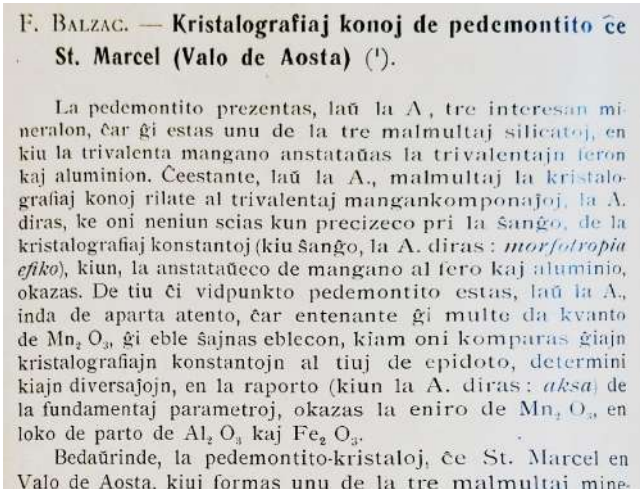
[31] A. Giron, *Une lieue de dentelle*, Hachette, Paris 1894, Gr. in-8°, 252 pp. *et pl.*; A. Giron, *Le Vieux ramasseur de pierres, suivi de la Famille de La Marjolaine...*, J. Hetzel, Paris 1898, 234 pp. *et pl.*

[32] Archivio storico dell'Università di Torino, Carteggio 1915/2a B, Fascicoli di personale, Personale volontario e tecnico.

[33] F. Balzac, *Le Artemisie dei Vermouths e dei Génépis*, in «Annali della R. Accademia di agricoltura di Torino», vol. 58, 1915, pp. 279-303.

Figure 4.5. Frangeat, alias Bertrand de Lom, seated at his desk in his cabinet.

Illustration from the novel *Une lieue de dentelle*, by Aimé Giron (1894). It is unclear whether this portrayal of Bertrand de Lom is true to reality.



F. Balzac. — **Kristalografiaj konoj de pedemontito ĉe St. Marcel (Valo de Aosta)** (1).

La pedemontito prezentas, laŭ la A., tre interesan mineralon, ĉar ĝi estas unu de la tre malmultaj silicatoj, en kiu la trivalenta mangano anstataŭas la trivalentajn feron kaj aluminion. Ĉeestante, laŭ la A., malmultaj la kristalografiaj konoj rilate al trivalentaj manganokomponaĵoj, la A. diras, ke oni neniun scias kun precizeco pri la ŝanĝo, de la kristalografiaj konstantoj (kiu ŝanĝo, la A. diras: *morfotropia efiko*), kiun, la anstataŭeco de mangano al fero kaj aluminio, okazas. De tiu ĉi vidpunkto pedemontito estas, laŭ la A., inda de aparta atento, ĉar entenante ĝi multe da kvanto de Mn_2O_3, ĝi eble ŝajnas eblecon, kiam oni komparas ĝiajn kristalografiajn konstantojn al tiuj de epidoto, determini kiajn diversaĵojn, en la raporto (kiun la A. diras: *aksa*) de la fundamentaj parametroj, okazas la eniro de Mn_2O_3, en loko de parto de Al_2O_3 kaj Fe_2O_3.

Bedaŭrinde, la pedemontito-kristaloj, ĉe St. Marcel en Valo de Aosta, kiuj formas unu de la tre malmultaj mine-

Figure 4.6. A study in esperanto on the crystallography of «pedemontito» (piemontite) from Saint-Marcel (1916).

This article, published during the First World War in «Rivista di Mineralogia e Cristallografia Italiana», was written by Ms Fausta Balzac, a mineralogist and assistente volontaria at the *Istituto di Mineralogia di Torino*. *La elekto de Fausta Balzac pri Esperanto meze de la Unua Mondmilito estis verŝajne batalema ago favore al internaciismo, en tempo markita de la plimalboniĝo de naciismoj* [Fausta Balzac's choice of Esperanto during the First World War was probably a militant act in favour of internationalism at a time of nationalist fervour].

prepare for a degree or access paid subordinate roles. Balzac published several papers on mineralogy, specialising primarily in the study of epidotes. Notably, she studied the piemontite from Praborna, a subject to which she devoted a very unusual paper written in Esperanto (Fig. 4.6)[34]. In the Jewish section of Turin cemetery, there is a tomb bearing the name Fausta Cifaratti, née Balzac, who died in 1926 after giving birth[35].

4.4 The plate tectonics revolution

Throughout the 19th and early 20th centuries, studies of the Praborna deposit focused almost exclusively on mineralogy, with very few geological studies being conducted. In 1881, Gerhard vom Rath classified the Praborna deposit as belonging to Gastaldi's *Pietre verdi* zone (which we would today call ophiolites), to which Secondo Franchi assigned a Mesozoic age in 1898[36]. Following Priehäusser's brief study in 1909, in which he attributed the manganese mineralisation to the percolation of mineral waters[37], Huttenlocher provided the first structural and geological descriptions of Praborna in 1934 and 1953 (Fig. 4.7)[38]. At the International Geological Congress in Mexico City in 1956, Falini described the Praborna deposit as a Mn-rich «concentration within shaly-cherty-calcareous sediments of geosyncline character, which include also basic igneous rocks». He added «the metamorphic actions due

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[34] F. Balzac, *Kristalografiaj konoj de pedemontito ĉe St. Marcel (Valo de Aosta)*, in «Rivista di Mineralogia e Cristallografia Italiana», vol. 47, 1916, pp. 86-93 ["Crystallographic knowledge of piemontite at St. Marcel (Aosta Valley)", in esperanto].

[35] G. Cifaratti, *Testimonianze e ricordi familiari*, in «Corriere del Ticino» (7 mars 2024, Massagno).

[36] G. vom Rath, *Prof. vom Rath legte einige durch Schönheit ausgezeichnete, von Herrn Stürtz hierselbst ihm anvertraute Mineralien aus dem Alathal und von e. a. Punkten Piemonts vor*, in «Sitzungsberichte der niederrheinischen Gesellschaft für Natur- und Heilkunde in Bonn [in: Verhandlungen des naturhistorischen Vereines der preussischen Rheinlande und Westfalens]», [Jahres 1881], 1882, pp. 215-231; S. Franchi, *Sull'età mesozoica della zona delle pietre verdi nelle Alpi occidentali*, in «Bollettino del R. Comitato Geologico d'Italia», vol. XXIX, 1898, pp. 173-247, 325-428 + pl.

[37] M. Priehäusser, *Die Manganlagerstätte von St. Marcel (Prabornaz) in Piemont*, in «Zeitschrift für praktische Geologie», vol. XVII (September 1909), 1909, pp. 396-399.

[38] H.F. Huttenlocher, *Die Erzlagerstättenzonen der Westalpen*, in «Schweizerische Mineralogische und Petrographische Mitteilungen», vol. 14, 1934, pp. 22-149 [pp. 77-85: *Die Manganlagerstätte des Val di S. Marcel*]; H.F. Huttenlocher, *Die Vererzung der Westalpen, ihre zeitliche und räumliche Gliederung*, in «Geologische Rundschau», vol. 42 (1), 1953, pp. 93-107 [p. 103: Manganerzlagerstätten].

to the orogenesis of the Alps gave origin to manganese-bearing neoproducts, mostly silicates, among which is remarquable the abundant piemontite»[39]. It is worth remembering that the geosyncline theory, which predated the theory of plate tectonics, explained mountain building through long, subsiding troughs (geosynclines) filled with marine sediment, which were later folded, metamorphosed and uplifted into mountain ranges such as the Alps due to the contraction of the Earth's crust.

Debenedetti in 1965, Dal Piaz in 1971 and Castello in 1981 showed the prevalence in the Aosta Valley of the association of Mn-rich metacherts and Fe–Cu sulphide deposits within oceanic metasediments, as is the case in Saint-Marcel[40]. Bearth and Schwandler (1981) emphasised the link between manganese deposits and ophiolites, viewing the latter as remnants of oceanic crust[41]. These studies paved the way for reinterpreting the Praborna deposit in light of the new theory of plate tectonics that emerged in the 1960s. This was achieved from 1975 to 2005 through several academic studies and doctoral theses.

Let us summarise this reinterpretation within the framework of plate tectonics. The metamorphosed ophiolites of the Zermatt-Saas Unit were first recognised as belonging to the Jurassic oceanic lithosphere of the «Piedmont Ocean», located between the European and African continents prior to the uplift of the Alps. As the Praborna rocks are interbedded within these meta-ophiolites, it has been suggested that the Praborna proto-ore has an oceanic hydrothermal origin. This was based on its geochemical similarities with other Mn-rich deposits that have been minimally affected by metamorphism. These included manganiferous cherts occurring in eastern Liguria, to which Bonatti

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[39] C.E. Burckhardt, F. Falini, *Memoria sui giacimenti italiani di manganese*, in J. Gonzàles Reyna (Ed.), *International Geological Congress 20th (Mexico); Symposium sobre yacimientos de manganeso*, vol. 5, 1956, pp. 221-272 [pp. 231-233].

[40] A. Debenedetti, *Il complesso radiolariti – giacimenti di manganese – giacimenti piritoso-cupriferi – rocce a fuchsite, come rappresentante del Malm nella Formazione dei Calcescisti. Osservazioni nelle Alpi Piemontesi e della Val d'Aosta*, in «Bollettino della Società Geologica Italiana», vol. 84 (1), 1965, pp. 131-163; G.V. Dal Piaz, *Alcune considerazioni sulla genesi delle ofioliti piemontesi e dei giacimenti ad esse associati*, in «Bollettino della Associazione mineraria subalpina», vol. 8, 1971, pp. 365-388; P. Castello, *Inventario delle mineralizzazioni a magnetite, ferro-rame e manganese del complesso piemontese dei calcescisti con pietre verdi in valle d'Aosta*, in «Ofioliti», vol. 6, 1981, pp. 5-46.

[41] P. Bearth, H. Schwandler, *The post-Triassic sediments of the ophiolite zone Zermatt-Saas Fee and the associated manganese mineralizations*, in «Eclogae Geologicae Helvetiae», vol. 74 (1), 1981, pp. 189-205.

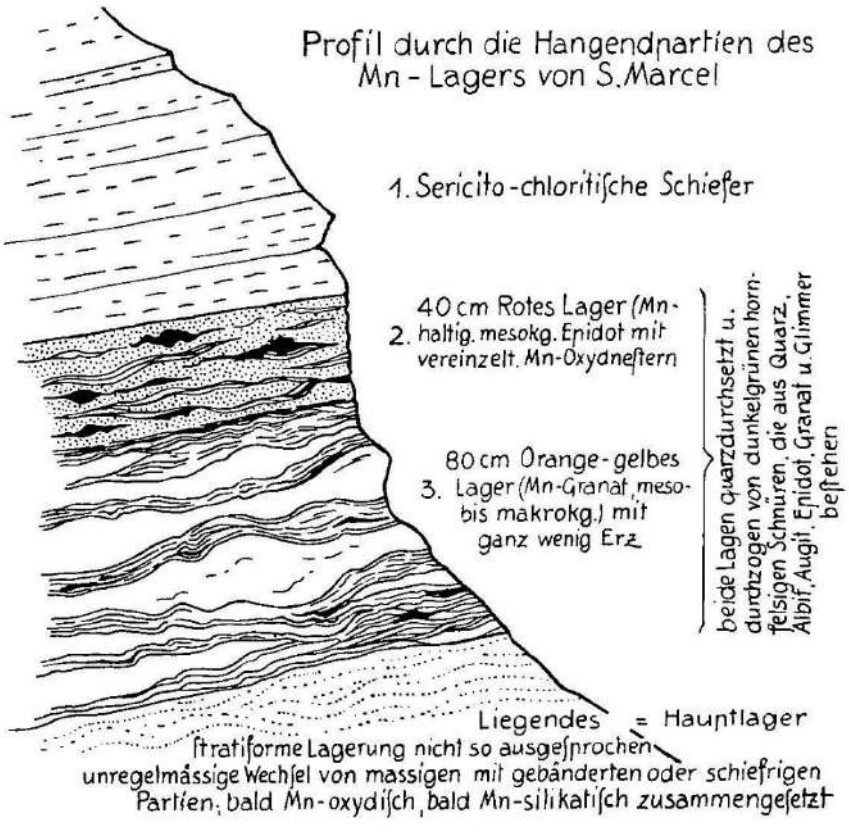

Figure 4.7. «Profile through the St Marcel Mn deposit», by H.F. Huttenlocher, *Die Erzlagerstättenzonen der Westalpen*, cit., fig. 4, p. 79.

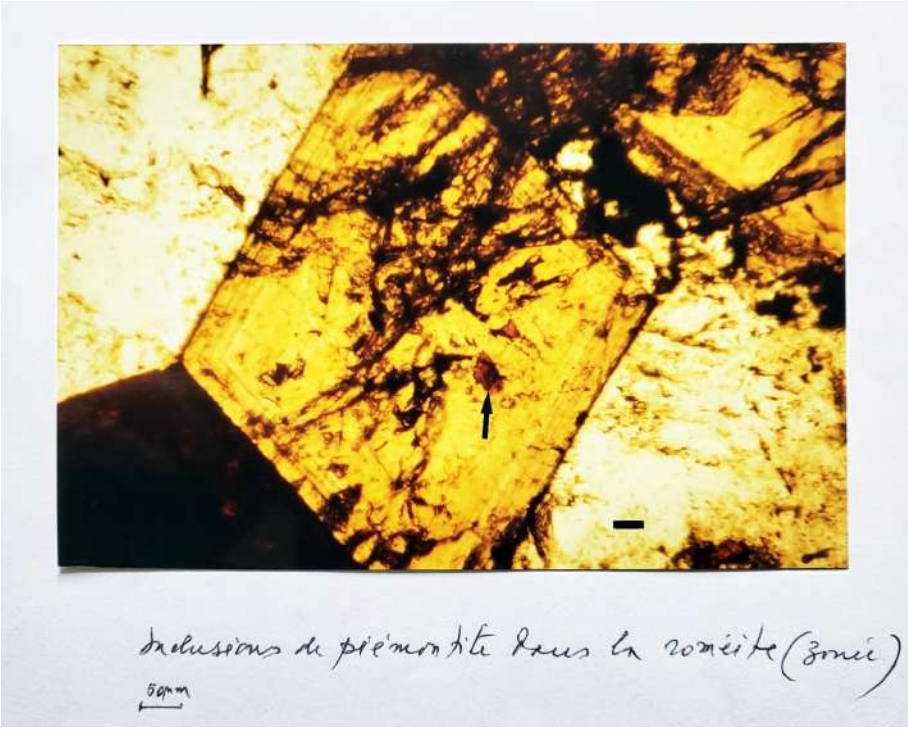

Figure 4.8. Photograph from Perseil's personal archives, representing a romeite crystal from Praborna. «inclusions of piemontite [arrow] in a zoned romeite crystal»; scale bar of 50 µm.

et al. (1976) assigned a hydrothermal origin[42], as well as similar deposits in other parts of the Alps[43]. On this basis, many authors inferred that the Praborna ore body may have formed at an oceanic spreading centre[44], emphasising the geochemical peculiarities of the Praborna metasediments (Section 5.3.1) and the abundance of sulphides in the nearby Fe–Cu Servette deposit[45], which is hosted in the same meta-ophiolites. These studies also provided detailed petrological and mineralogical analyses, showing that the Praborna rocks had undergone metamorphism under high-pressure eclogite-facies conditions. This has been interpreted as being due to the burial of the Piedmont Ocean lithosphere at great depths, resulting from subduction. Another peculiarity of this metamorphism is the persistence of a high degree of oxidation in the manganese ore during subduction[46].

Alongside geological studies, mineralogical and crystallographic studies of the minerals of Praborna have benefited from new techniques such as X-ray diffraction and microanalysis. Initially conducted using optical microscopy in reflected light[47], studies of the manganese ores of Praborna were contin-

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[42] E. Bonatti, M. Zerbi, R. Kay, H. Rydell, *Metalliferous deposits from the Apennine ophiolites: Mesozoic equivalents of modern deposits from oceanic spreading centers*, in «Geological Society of America Bulletin», vol. 87, 1976, pp. 83-94.

[43] E.g., C. Chopin, *Les paragenèses réduites ou oxydées de concentrations manganésifères des «schistes lustrés» de Haute-Maurienne (Alpes françaises)*, in «Bulletin de Minéralogie», vol. 101, 1978, pp. 514-531.

[44] W.L. Griffin, A. Mottana, *Crystal chemistry of clinopyroxenes from the St. Marcel manganese deposit, Val d'Aosta, Italy*, in «American Mineralogist», vol. 67, 1982, pp. 568-586; A. Mottana, *Blueschist-facies metamorphism of manganiferous cherts: a review of the alpine occurrences*, in «Geological Society of America Memoirs», vol. 164, 1986, pp. 267-299; S. Martin, J.R. Kiénast, *The HP-LT manganiferous quartzites of Praborna, Piemonte ophiolite nappe, Italian Western Alps*, in «Schweizerische Mineralogische und Petrographische Mitteilungen», vol. 67 (1-2), 1987, pp. 339-360; S. Tumiati, S. Martin, G. Godard, *Hydrothermal origin of manganese in the high-pressure ophiolite metasediments of Praborna ore deposit (Aosta Valley, Western Alps)*, in «European Journal of Mineralogy», vol. 22 (4), 2010, pp. 577-594.

[45] G.V. Dal Piaz, P. Omenetto, *Brevi note su alcune mineralizzazione della falda piemontese in Valle d'Aosta*, in «Ofioliti», 3 (2/3), 1978, pp. 161-176. P. Tartarotti, *Le ofioliti piemontesi nella media e bassa valle di St. Marcel (Aosta)*, Tesi di dottorato, Università di Padova, Padova, 1988, 167 pp.

[46] S. Tumiati, G. Godard, S. Martin, N. Malaspina, S. Poli, *Ultra-oxidized rocks in subduction mélanges? Decoupling between oxygen fugacity and oxygen availability in a Mn-rich metasomatic environment*, in «Lithos», vol. 226, 2015, pp. 116-130.

[47] See in particular: J. Orcel, S. Pavlovitch, *Les caractères microscopiques des oxydes de man-*

ued using scanning electron microscopy from the 1980s onwards. Between 1960 and 2020, approximately fifty studies focused on the crystallography and crystallochemistry of Praborna minerals, including piemontite, pyroxenes (particularly violan), garnets (such as calderite), romeite, etc.[48]

Elena-Adriana Perseil authored or co-authored fifteen of these studies, which were mostly dedicated to apatite, titanite, romeite and various oxides (Fig. 4.8). After graduating from the Bucharest School of Mines in Romania, she presented her first thesis, devoted to the geological and metallogenic study of the middle part of the Arize Massif (Ariège, France), at the Sorbonne university (Paris) in 1962. She then prepared her *thèse d'État* on the metallogeny of manganese in southern France, defending it at the University of Toulouse in 1968. During a visit to the Soviet Union, her Russian colleague, Igor M. Varentsov, drew her attention to the Praborna deposit, which she began studying upon her return to France. As a research fellow at the *Centre National de la Recherche Scientifique*, she worked in the mineralogy laboratory at the *Muséum National d'Histoire Naturelle* in Paris, where she dedicated much of her scientific career to studying manganese minerals, particularly those from Praborna. Whereas Perseil's work primarily focused on apatite, titanite, romeite and oxides, crystallographic studies of pyroxenes, particularly violan, amphiboles and piemontite from Praborna were mainly carried out by Annibale Mottana, William Griffin and the crystallography team at the University of Pavia, led by Giuseppe Rossi and Luciano Ungaretti.

Between 1979 and 1982, Silvana Martin worked on her thesis regarding the Praborna manganiferous quartzites at the Université Pierre et Marie Curie (UPMC) in Paris, under the supervision of Jean-Robert Kiénast for the silicates and Adriana Perseil for the non-silicates[49]. From 1986 to 1988, Janusz Mozgawa continued the study of the Praborna deposit from a geochemical point of view, still at UPMC[50]. Finally, between 2002 and 2005, Simone

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ganèse et des manganites naturels (détermination de leurs pouvoirs réflecteurs), in «Bulletin de la Société française de Minéralogie», vol. 54 (5-8), 1931, pp. 108-179.

[48] Please refer to the bibliography, in particular for following names: Bondi, Griffin, Mottana, Perseil, Rossi and Smith.

[49] S. Martin-Vernizzi, *La mine de Praborna (Val d'Aoste, Italie): une série manganésifère métamorphisée dans le faciès éclogite*, Thèse de doctorat de 3ème cycle, Université Paris VI, Paris, 1982, 215 pp. + bibliographie + analyses.

[50] J. Mozgawa, *Comportement des éléments majeurs et traces au cours du métamorphisme éclogitique d'une série océanique manganésifère (mine de Praborna, Val d'Aoste)*, Thèse de doctorat de 3ème cycle, Université Paris VI, Paris, 1988, 142 pp.

Tumiati furthered the mineralogical and petrological study of Praborna under the guidance of Gaston Godard (Université Denis-Diderot, Paris) and Silvana Martin (Università dell'Insubria, Como)[51].

At the same time, passionate mineralogists, often amateurs – in the etymological sense of the word: who love –, have conducted diligent fieldwork in search of rare and even new minerals in Praborna, Varenche and other similar occurrences in the Aosta Valley. Over the past 50 years, some 50 articles recounting this research have been published in books and in regional or national periodicals, commonly illustrated with photographs of superb crystals. The Aosta Valley geologist Paolo Castello, Antonello Barresi of Turin, Raffaele Prete, who kindly granted us permission to reproduce some of his photographs, and many others have continued the ongoing inventory of minerals from Praborna and Varenche.

The geological and mineralogical studies devoted to Praborna were particularly numerous after the Second World War. They are listed in the bibliography at the end of this memoir. They have greatly enriched our current knowledge of Praborna, a synthesis of which is provided in Chapters 5 (Geology) and 6 (Mineralogy).

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[51] S. Tumiati, *Geochemistry, mineralogy and petrology of the eclogitized manganese deposit of Praborna (Valle d'Aosta, Western Italian Alps)*, Dottorato di Scienze ambientali, Università degli studi dell'Insubria, Como; Doctorat des Sciences physiques de la Terre, Université Paris 7 - Denis Diderot, 2005, 241 pp.

Chapter 5

Geology and Petrology

5.1 Geological context

The Piedmont ophiolite nappe in the Western Alps has long been recognised as a formation particularly rich in iron, copper-iron and manganese deposits[1] (Fig. 5.1). Over the past few centuries, geologists have documented the occurrence of manganiferous layers associated with siliceous rocks such as metachert and quartzite, which formed after the Triassic period[2]. Over millions of years, these rocks were affected by the Alpine orogeny – the mountain-building processes that shaped the Alps. Consequently, they underwent strong metamorphism (changes due to pressure and temperature) and structural reworking, transforming their original mineralogy. These rocks typically consist of quartz, piemontite, braunite and Mn-rich garnets, usually in association with Mn-rich white micas. Geologists have also documented the presence of many other Mn-bearing minerals, including clinopyroxenes, amphiboles, pyroxenoids (rhodonite, pyroxmangite), ardennite, carbonates (rhodochrosite), epidotes (piemontite, androsite), as well as tourmaline, apatite, hematite, rutile and titanite[3]. All manganiferous deposits in the Western Alps, the best-developed of which is Praborna in the Saint-Marcel Valley, share similar

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https://doi.org/10.14672/QUAD2026-47-6

[1] H.F. Huttenlocher, *Die Erzlagerstättenzonen der Westalpen*, cit.; A. Debenedetti, *Il complesso radiolariti – giacimenti di manganese – giacimenti piritoso-cupriferi – rocce a fuchsite…*, cit.; G.V. Dal Piaz, *Alcune considerazioni sulla genesi delle ofioliti piemontesi e dei giacimenti ad esse associati*, cit.; S. Martin, G. Godard, G. Rebay, *The subducted Tethys in the Aosta Valley (Italian western Alps)*, Pre-congress field trip guide-book, B02 5-day excursion, The 32[d] International Geological Congress, Firenze 2004.

[2] G.V. Dal Piaz, G. Di Battistini, J.R. Kiénast, G. Venturelli, *Manganesiferous quartzitic schists of the Piemonte ophiolite nappe in the Valsesia-Valtoumanche area (Italian Western Alps)*, in «Memorie di Scienze Geologiche [Padova]», vol. 32, 1979, pp. 1-24.

[3] G.V. Dal Piaz *et al*., *Manganesiferous quartzitic schists of the Piemonte ophiolite nappe in the Valsesia-Valtoumanche area (Italian Western Alps)*, cit.; S. Martin, J.R. Kiénast, *The HP-LT manganiferous quartzites of Praborna, Piemonte ophiolite nappe, Italian Western Alps*, cit.; S. Tumiati *et al*., *Hydrothermal origin of manganese in the high-pressure ophiolite metasediments of Praborna ore deposit (Aosta Valley, Western Alps)*, cit.; S. Tumiati *et al*., *Ultra-oxidized rocks in subduction mélanges? Decoupling between oxygen fugacity and oxygen availability in a Mn-rich metasomatic environment*, cit.

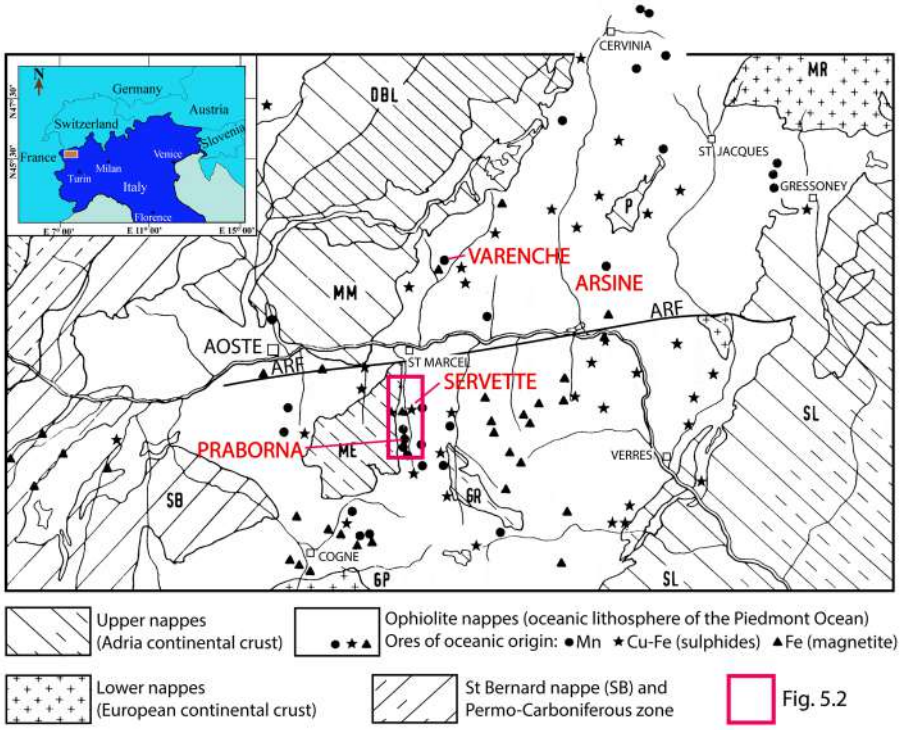

Figure 5.1. Geological sketch map of the Aosta Valley, showing the Mn, Cu-Fe and Fe ore occurrences in the Piedmont ophiolite nappes.

ARF: Aosta-Ranzola Fault;
SB: Saint Bernard nappe;
GP and MR: Gran Paradiso and Monte Rosa nappes;
MM, DBL, ME and SL: Mont Mary, Dent Blanche, Monte Emilius and Sesia-Lanzo Austroalpine nappes and *klippen*.

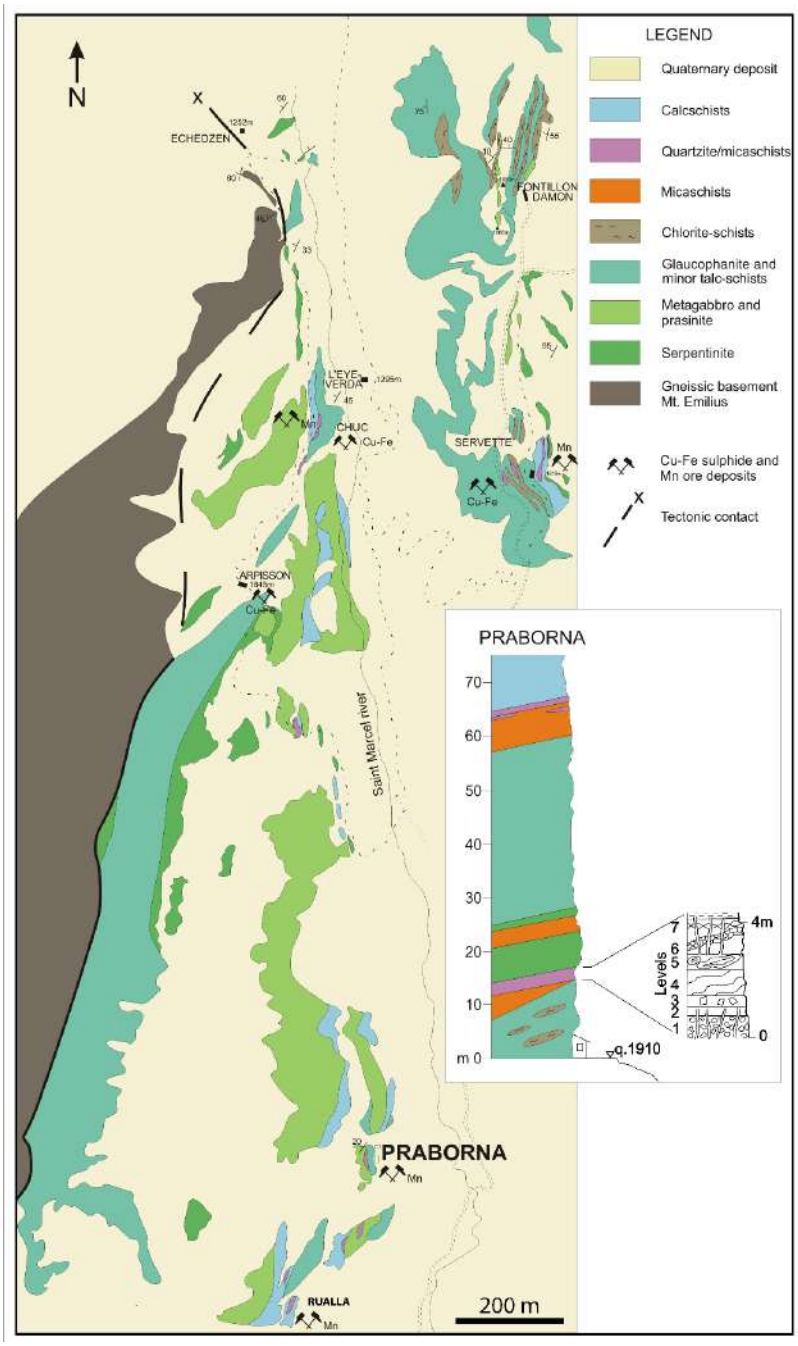

Figure 5.2. Geological map of the Saint-Marcel Valley.

features. They typically appear as layers ranging in thickness from 1 centimetre to several metres, commonly repeated in a banded fashion. These layers may contain lenses several metres thick, which are made of massive Mn-rich oxides (braunite, hausmannite, jacobsite) associated with fine-grained quartz. They are interbedded within quartz micaschists, and exhibit a characteristic rhythmic banding. The Mn-rich layers have a striking appearance in the field, commonly showing vivid shades of violet, reddish, orange or yellow, whereas the surrounding quartzites and micaschists, which are poor in manganese, typically appear white, grey or pale green.

Praborna is located in the Saint-Marcel Valley, a lateral valley of the Aosta Valley in the Western Italian Alps (Fig. 5.2). Extending from south to north for almost 10 km, the valley runs from its head near Cogne in the Urtier Valley to the village of Saint-Marcel. Two distinct geological units meet here: an ancient continental crust, which was part of the African margin (Adria), and an oceanic crust that belonged to the Mesozoic Tethys Ocean. Both were caught up in the Alpine collision between around 70-40 million years ago, which formed the Western Alps. The continental crust forms the Monte Emilius klippe, which is dominated by high-grade gneisses. The oceanic unit is made of metagabbros, metabasalts and serpentinites – rocks that originally formed the ocean floor – as well as the metasediments that covered them: limestone, micaschists and quartzite (Fig. 5.2). These rocks, known as ophiolites, are fragments of the Tethyan lithosphere, and were once close to a mid-ocean ridge where hydrothermal vents produced Cu-Fe-rich and Mn-bearing deposits. When the Tethyan Ocean closed and its lithosphere was subducted beneath the Adria continental crust, these rocks were dragged down to depths of 60-80 km. They underwent folding and high-pressure metamorphism, turning into «meta-ophiolites». Minerals that are stable at extreme pressures and intermediate temperatures then crystallised, reaching eclogite-facies conditions. In the Saint-Marcel Valley, the meta-ophiolites include lawsonite-bearing glaucophanites (i.e., metabasalts), metagabbros, talc-schists and serpentinites, as well as metasediments such as garnet–chloritoid–glaucophane micaschists, calc-schists, marbles and Mn-rich quartzites.

5.2 Description of the Praborna manganiferous ore body

The Praborna ore deposit is located in the middle section of the Saint-Marcel Valley (Figs. P.1, 5.1, 5.2). The ore body consists of manganiferous clinopyroxenites and quartzites containing a four-metre-thick lens rich in braunite, hausmannite and other manganese oxides. The main mineralised lens extends

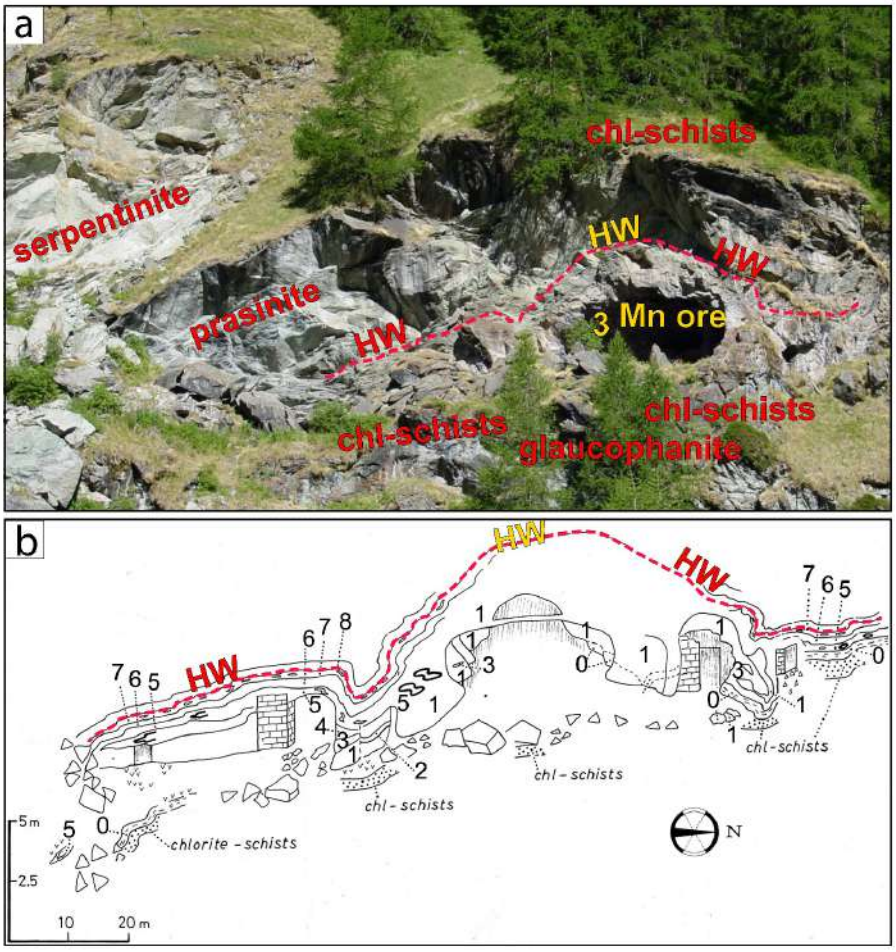

Figure 5.3. Geological field sketch of the Praborna mine.

HW: hanging wall of the Mn-rich levels; 0 to 8: level numbers (see text).

from southeast to northwest with a 15-degree dip to the northwest (Fig. P.4), and was exploited along two superposed galleries (Fig. P.3d). The main ore body is associated with banded clinopyroxenites and quartzites that are rich in piemontite, Mn-rich garnets (spessartine, calderite) and Mn-rich micas (alurgite, phlogopite). These banded rocks appear as layers ranging in thickness from one centimetre to several metres, because they are commonly repeated by isoclinal folds. Despite these repetitions, a sequence of levels characterised by a specific mineralogy can be identified throughout the deposit, albeit with highly variable thicknesses (Fig. 5.3b). Below, we present a short description of these levels, which are numbered from bottom to top[4].

5.2.1 Level 0

The footwall of the Mn-rich horizon is in contact with an underlying garnet-bearing glaucophanite, which exhibits cm-sized pseudomorphs after prismatic lawsonite (Fig. 5.4a). These rocks have undergone local retrogression and are associated with chlorite-schists.

5.2.2 Level 1

The basal Level 1 of the manganiferous sequence consists mainly of clinopyroxenite and braunite-rich quartzite, which was preferentially mined. The clinopyroxenite primarily consists of violet or bluish Mn-bearing jadeite-aegirine-augite solid solutions (i.e., «violan»). The black braunite-rich quartzite is made of braunite and other manganiferous oxides, as well as quartz. It is highly fractured and shows several generations of veins with a nearly vertical orientation (Fig. 5.4c). Most of these veins are confined to the massive ore bodies and do not extend into the surrounding rocks, suggesting that they formed due to the high rigidity of the ore during stretching. A first generation of veins consists of quartz**,** piemontite, Mn-rich sodic amphibole, Mn-bearing jadeite and Mn-rich micas (alurgite, phlogopite), whereas the latest veins are filled with quartz, albite, piemontite, tremolite, calcite or rhodochrosite.

5.2.3 Level 2

The reddish Layer 2, which is typically 20 cm thick, is dominated by epidotes, primarily piemontite and androsite-(Ce), alongside braunite and quartz

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[4] For a more precise description of these levels, the reader is invited to consult the following doctoral theses: S. Martin-Vernizzi, *La mine de Praborna (Val d'Aoste, Italie): une série manganésifère métamorphisée dans le faciès éclogite*, cit.; S. Tumiati, *Geochemistry, mineralogy and petrology of the eclogitized manganese deposit of Praborna (Valle d'Aosta, Western Italian Alps)*, cit.

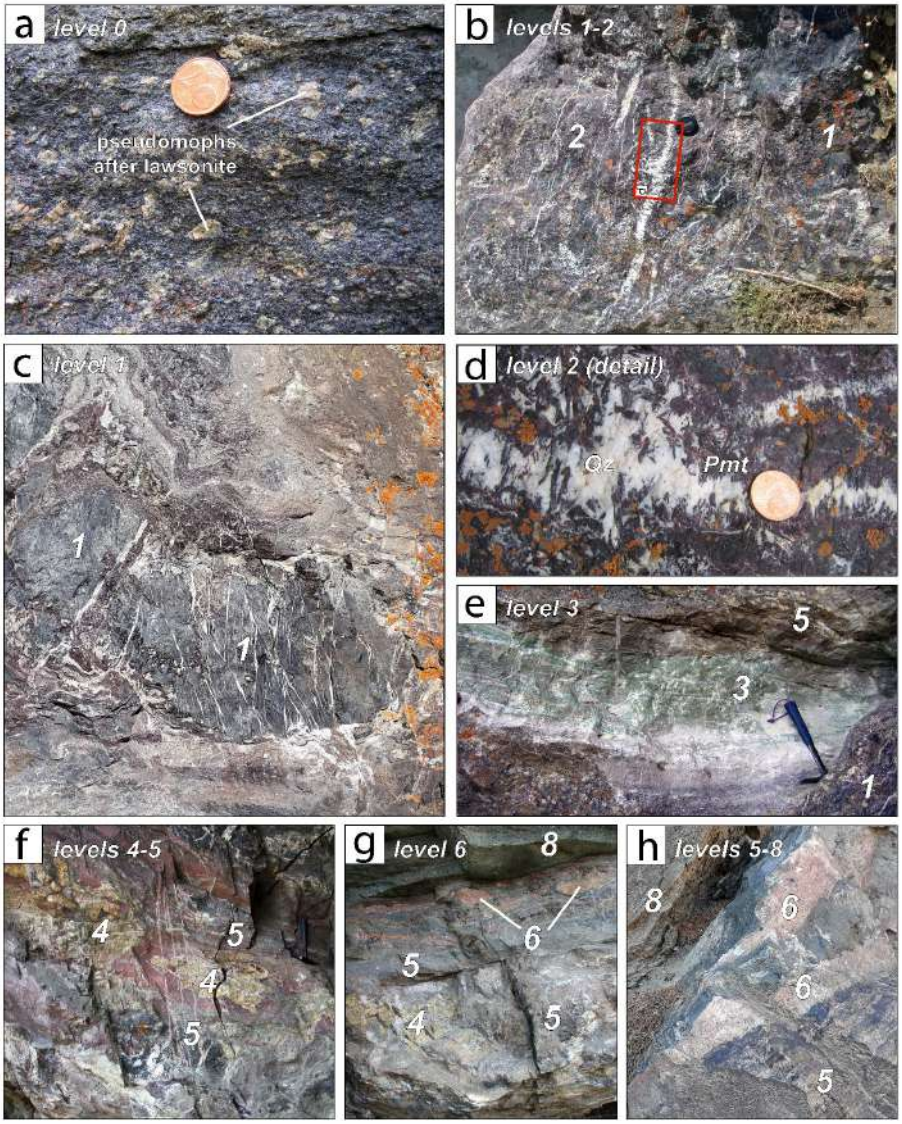

Figure 5.4. Photographs of the main levels at Praborna.

These levels are numbered from 0 to 8 (from bottom to top) and described in Section 5.2.

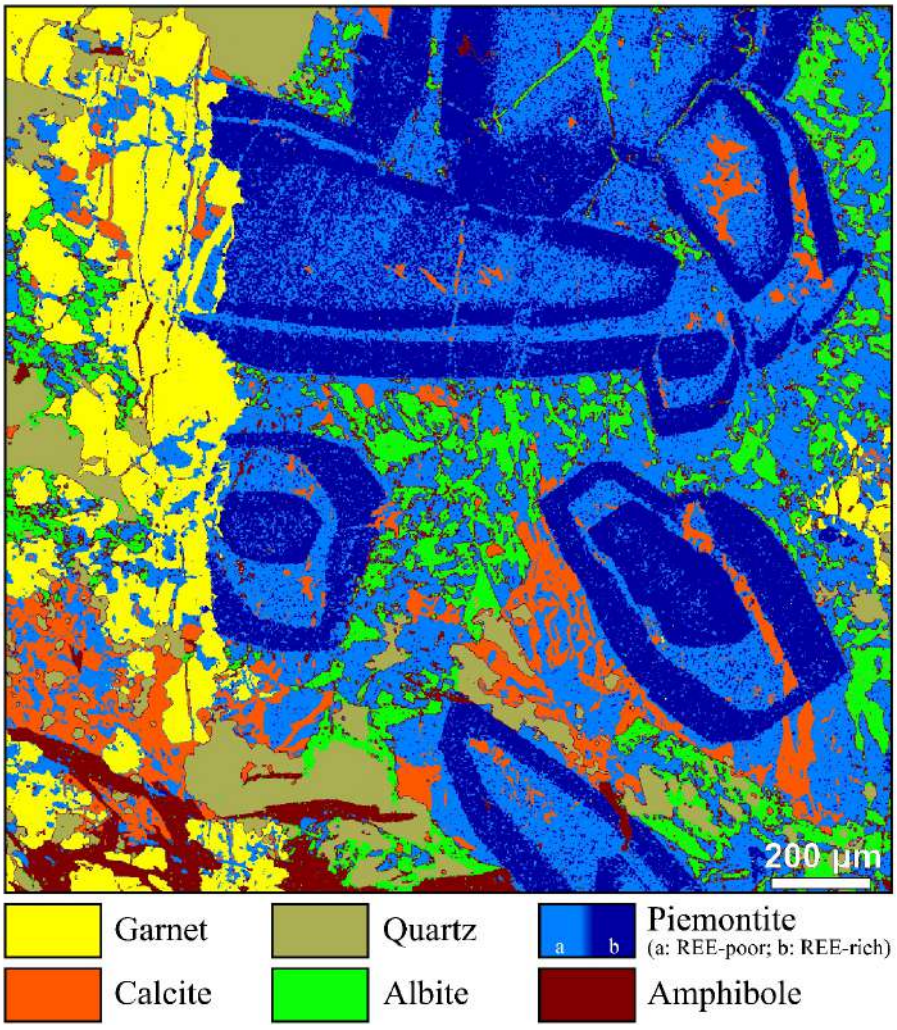

Figure 5.5. A microscopic view of a vein rich in piemontite showing oscillatory zoning (on the right) and its host rock (on the left) from Level 2. The image was created using mineral classification from elemental maps obtained at the scanning electron microscope.

(Fig. 5.4b, d). Sodic clinopyroxenes are less abundant than in Level 1, but the pyroxenoid pyroxmangite has been reported. Yellow bands of Mn-rich garnet are also common. Accessory phases include As- and Sb-bearing minerals, such as Sb-rich rutile and titanite, ardennite, roméite and As-rich apatite. Veins contain piemontite rich in REEs, sodic amphibole, albite, microcline and barite (Figs. 5.4d; 5.5).

5.2.4 Level 3

This is a discontinuous, emerald-green layer, up to 20 cm thick, consisting of Cr- and V-bearing aegirine-rich omphacite (Jd_{70}), which occurs alongside quartz (Fig. 5.4e). Accessory phases include: Cr-rich phengite (fuchsite or mariposite); Mn-rich epidotes bearing Cr and REE; Cr-rich garnet (uvarovite); Cr-bearing amphibole (winchite-tremolite solid solution); Cr-bearing hematite and braunite; As-bearing apatite; native gold; wakefieldite, an (REE, Ca)-vanadate.

5.2.5 Levels 4 and 5

Level 4 contains metre-sized, yellowish lenses made of calderite-rich garnet with small amounts of hematite set within a quartz-rich matrix (4 in Fig. 5.4f). These lenses are surrounded by 10 cm-thick reddish bands, which consist of fine-grained piemontite and quartz and are free of garnet. These bands pass to Level 5 (5 in Fig. 5.4f), where brownish layers contain aegirine-rich clinopyroxene and dark green sodic amphibole alongside garnet and quartz. The accessory minerals of Level 5 include pyroxmangite, Sb-bearing pyrophanite, hematite, Mn–Ca carbonates, apatite and Mn-rich epidotes. In levels 4 and 5, Mn^{2+} is dominant over Mn^{3+}, suggesting a drop in the chemical potential of oxygen relative to the basal levels.

5.2.6 Level 6

This level consists of 10 cm-thick pinkish lenses boudinaged within pyroxenites of Level 5 (6 in Fig. 5.4g, h). They are made of quartz, pyroxmangite (partially transformed into rhodonite), garnet and dark-coloured manganocummingtonite. The garnet crystals are strongly zoned showing high concentrations of the end-members calderite, spessartine and henritermierite (i.e., $(Mn^{2+}, Ca)_3(Fe^{3+}, Al^{3+}, Mn^{3+})_2[SiO_4]_3$) in their cores and are spessartine-rich at their rims. Manganiandrosite-(Ce) and hematite occur as accessory minerals; Sb-rich pyrophanite developed after hematite. Compared with levels 4 and 5, Level 6 contains abundant pyroxenoid pyroxmangite and epidote manganiandrosite-(Ce) instead of piemontite.

5.2.7 Levels 7 and 8

The roof of the ore (Level 7) is composed of quartz, pink Mn-rich garnet (spessartine) and Mn–Ca carbonates (rhodochrosite, kutnahorite). Manganese is here exclusively Mn^{2+}. Level 7 is overlain by the country rocks (Level 8), which consist of manganese-poor micaschists and chlorite-schists, and further up, prasinite, talc-schists and serpentinite (Fig. 5.3a).

5.2.8 Quartz-free rocks

Several samples taken from the mine dumps exhibit unusual parageneses that do not clearly correspond to any of the above-described levels. These include silica-deficient samples lacking quartz, in which Mn-bearing olivine (tephroite) has been observed.

A unique sample (C4), discovered in the mine spoils by Paolo Mietto and studied by Celeste Micaglio, Tumiati and Tumiati *et al*.[5], may have originated from the lower levels of Praborna, given its high Mn-content and the veins it contains. It is quartz-free, rich in Mn-bearing olivine (tephroite; $Tep_{98.6}$), which occurs alongside hausmannite, rhodochrosite and, to a lesser extent, braunite and pyroxmangite. The veins are primarily composed of rhodonite and rhodochrosite.

Another silica-undersaturated, 5 cm-sized, fragment has also been sampled in the dumps by Christian Chopin and described by Cenki-Tok *et al*.[6] It consists of fine-grained tephroite and rhodochrosite, with minor amounts of hematite, calderite, pyrophanite, jacobsite and manganiandrosite-(Ce). The fragment is surrounded by a cm-thick reaction corona of rhodochrosite, pyroxenoid and spessartine, transitioning into a host quartz-bearing vein.

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[5] C. Micaglio, *Le ardenniti di St. Marcel e di Chambave (Valle d'Aosta)*, Tesi di Laurea in Scienze naturali, Università degli studi di Padova, Padova, 2003-2004, 45 pp. + appendici; S. Tumiati, *Geochemistry, mineralogy and petrology of the eclogitized manganese deposit of Praborna (Valle d'Aosta, Western Italian Alps)*, cit., pp. 118-119; S. Tumiati *et al*., *Ultra-oxidized rocks in subduction mélanges? Decoupling between oxygen fugacity and oxygen availability in a Mn-rich metasomatic environment*, cit.

[6] B. Cenki-Tok, C. Chopin, *Coexisting calderite and spessartine garnets in eclogite-facies metacherts of the Western Alps*, in «Mineralogy and Petrology», vol. 88, 2006, pp. 47-68; B. Cenki-Tok, A. Ragu, T. Armbruster, C. Chopin, O. Medenbach, *New Mn-and rare-earth-rich epidote-group minerals in metacherts: manganiandrosite-(Ce) and vanadoandrosite-(Ce)*, in «European Journal of Mineralogy», vol. 18 (5), 2006, pp. 569-582.

5.3 Petrological evolution

5.3.1 Origin of the manganiferous proto-ore

Geologists have long been intrigued by the question of how the original Praborna ore formed. Following the emergence of the theory of plate tectonics, it was proposed in the 1980s that the Praborna proto-ore may have formed at an oceanic spreading centre (Section 4.4), as indicated by the high concentrations of Ba and Sr, and the high Si/Al ratio in the Praborna quartzites. More recently, Tumiati *et al*. (2010) compared the Praborna rocks with modern oceanic manganese deposits, which are forming on the seafloor today[7]. They demonstrated that, although the Praborna Mn-rich sequence exhibits heterogeneity in terms of chemistry and mineralogy, the composition of its various layers follows the trend observed in modern hydrothermal Fe–Mn deposits, whereas they differ from the hydrogenous sediments consisting of nodules and encrustations derived from the low precipitation of these elements from normal seawater (Fig. 5.6). The authors also concluded that the geochemical signature was preserved during high-pressure metamorphism, although trace elements and REEs were somewhat linked to the mineralogy. For instance, samples rich in piemontite are enriched in light REEs, whereas garnet-bearing samples are richer in heavy REEs and Y. As mineralogy is controlled by the composition of the major elements, these correlations may imply the partial redistribution of trace elements and REEs at the sample or outcrop scales during metamorphism. Indeed, the oscillatory zoning of the piemontite in the veins (Fig. 5.5) indicates that these elements were mobile to some extent. Furthermore, the widespread presence of Mn^{3+}-bearing minerals, such as piemontite and braunite, in the preserved core of the Praborna ore (i.e., Levels 1-2) suggests that the high oxygen chemical potential, typical of original oceanic Mn^{4+}-bearing hydrothermal deposits, was retained to some extent during metamorphism. Finally, the protolith of the peculiar Cr-bearing Level 3, which contains carbonates and gold, may have been listvenite – an unusual rock formed through the alteration of serpentinite. The metabasalts (now glaucophanite), metasediments and serpentinite present at the base and top of the Praborna sequence are also typical of a metamorphosed oceanic lithosphere.

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[7] S. Tumiati, S. Martin, G. Godard, *Hydrothermal origin of manganese in the high-pressure ophiolite metasediments of Praborna ore deposit (Aosta Valley, Western Alps)*, cit.

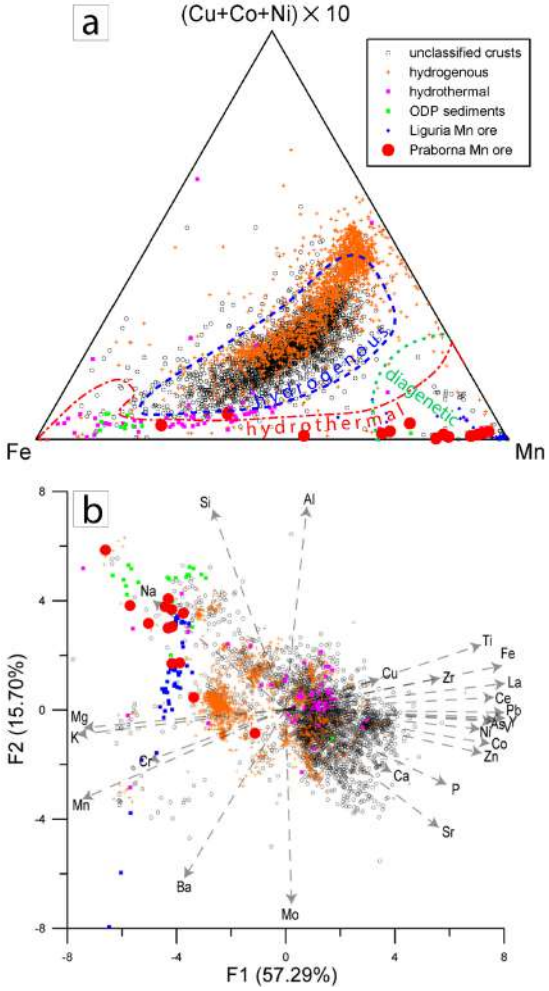

Figure 5.6. Comparison of manganiferous Praborna and Liguria deposits with modern hydrogenous and hydrothermal Mn-rich oceanic deposits.

(a) Mn–Fe–(Co+Ni+Cu) × 10 ternary diagram; the fields hydrogenous, hydrothermal and diagenetic are from D. Kwon *et al.*, *Deep-sea environmental conditions reflected in mineral phases of manganese nodules and their implications for Ni, Co, and Cu geochemistry*, in «Front. Mar. Sci.», 2025, 12:1707329;

(b) diagram showing the first two principal components (F1, F2) of the principal component analysis (the % values represent the corresponding eigenvalues of the correlation matrix).

Modified after Tumiati *et al.* (2010).

5.3.2 High-pressure metamorphism

The occurrence in the Mn-rich metasediments of Praborna of omphacite+quartz, as well as pyroxmangite (the high-pressure polymorph of $Mn^{2+}SiO_3$) and calderite, indicates that these rocks equilibrated at high-pressure eclogite-facies metamorphic conditions[8]. The presence of lawsonite-bearing glaucophanite at the base of the sequence also indicates that the rocks formed under high-pressure conditions. However, the thermodynamic modelling techniques that are commonly used to accurately estimate the P-T conditions of metamorphism in metabasites and metapelites – namely, the P-T pseudosection method – cannot be easily applied to the unusual Mn-rich chemical composition of the Praborna rocks. Furthermore, the stability of the mineral associations observed at Praborna depends not only on pressure and temperature, but also on the chemical potential of oxygen, which varies from level to level and controls manganese valency[9]. The metamorphic peak conditions at Praborna can also be inferred from nearby metaophiolites, such as those at Servette (Saint-Marcel) where peak P-T conditions of 2.1 GPa and 550 °C have been deduced[10]. It is reasonable to assume that these conditions also represent the eclogite-facies peak conditions at Praborna.

Under these eclogite-facies conditions, the Praborna rocks underwent a strong deformation, which was responsible for isoclinal folding and the development of the main foliation. This deformation also resulted in the recrystallisation of the rocks, erasing most traces of the early metamorphic history. However, evidence of the prograde evolution is preserved in the core of some crystals. The zoned garnet crystals in Level 4, for instance, have spessartine cores containing hematite inclusions that evolve into calderite-rich rims, indicating an increase of pressure during garnet growth (Fig. 6.5c)[11].

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[8] B. Cenki-Tok, C. Chopin, *Coexisting calderite and spessartine garnets in eclogite-facies metacherts of the Western Alps*, cit.; S. Tumiati *et al*., *Ultra-oxidized rocks in subduction mélanges? Decoupling between oxygen fugacity and oxygen availability in a Mn-rich metasomatic environment*, cit.

[9] S. Tumiati *et al*., *Ultra-oxidized rocks in subduction mélanges? Decoupling between oxygen fugacity and oxygen availability in a Mn-rich metasomatic environment*, cit.

[10] S. Martin, G. Rebay, J.-R. Kiénast, C. Mevel, *An eclogitised oceanic palaeohydrothermal field from the St. Marcel Valley (Italian Western Alps)*, in «Ofioliti», vol. 33, 2008, pp. 1-15.

[11] B. Cenki-Tok, C. Chopin, *Coexisting calderite and spessartine garnets in eclogite-facies metacherts of the Western Alps*, cit.; S. Tumiati, *Geochemistry, mineralogy and petrology of the eclogitized manganese deposit of Praborna (Valle d'Aosta, Western Italian Alps)*, cit.

The Praborna rocks are riddled with numerous veins, which are particularly abundant in basal Level 1 (Section 5.2.2). These veins are evidence of the circulation of silica-rich aqueous fluids at depth. The fractures were filled with quartz alongside various minerals that are typical of either eclogite facies (omphacite, in particular the «violan» variety, jadeite, aegirine, hausmannite and pyroxmangite), blueschist facies (REE-rich piemontite [Fig. 5.5], Na-clinoamphiboles, alurgite, rhodonite, Mn-phlogopite, microcline and hematite), or greenschist facies (albite, tremolite, calcite, rhodochrosite, pyrolusite and cryptomelane)[12]. The presence of these veins of various generations indicates a continuum of fracturing during retrograde evolution.

5.3.3 Retrogression

The transition from eclogite-facies to greenschist-facies conditions in the Praborna rocks is evidenced by the replacement of high-pressure minerals by symplectites. As a symplectite consists of a microscopic intergrowth of several minerals that have replaced an unstable parent mineral formed at great depths under high-pressure conditions, its presence indicates an exhumation towards the Earth's surface.

Three main types of symplectite have been observed at Praborna, depending on the mineral that was replaced: those formed after clinopyroxene, piemontite, and alurgite.

The jadeite-rich clinopyroxenes are partly or totally transformed into symplectites, which consist mainly of albitic plagioclase and a secondary, jadeite-poor clinopyroxene (Fig. 5.7a, b). This metamorphic reaction approaches the well-known univariant reaction: Jadeite ($NaAlSi_2O_6$) + Quartz (SiO_2) → Albite ($NaAlSi_3O_8$), which occurs when pressure decreases during exhumation. In the Praborna rocks, however, jadeite is in solid solution within high-pressure sodic clinopyroxenes, such as omphacite and violan, which can be considered as impure jadeite, so the actual reaction is closer to the following: $(\text{Jadeite}_x\ \text{Augite}_{1-x}) + x$ Quartz → x Albite + $1\text{-}x$ Augite. Here, $(\text{Jadeite}_x\ \text{Augite}_{1-x})$ represents the parent omphacite, whereas «Albite» and «Augite» are the main products observed in the symplectite. Since omphacite also contains minor elements such as Fe^{3+}, V and Cr, particularly in the emerald-green

[12] S. Martin, J.R. Kiénast, *The HP-LT manganiferous quartzites of Praborna, Piemonte ophiolite nappe, Italian Western Alps*, cit.; S. Tumiati, *Geochemistry, mineralogy and petrology of the eclogitized manganese deposit of Praborna (Valle d'Aosta, Western Italian Alps)*, cit.

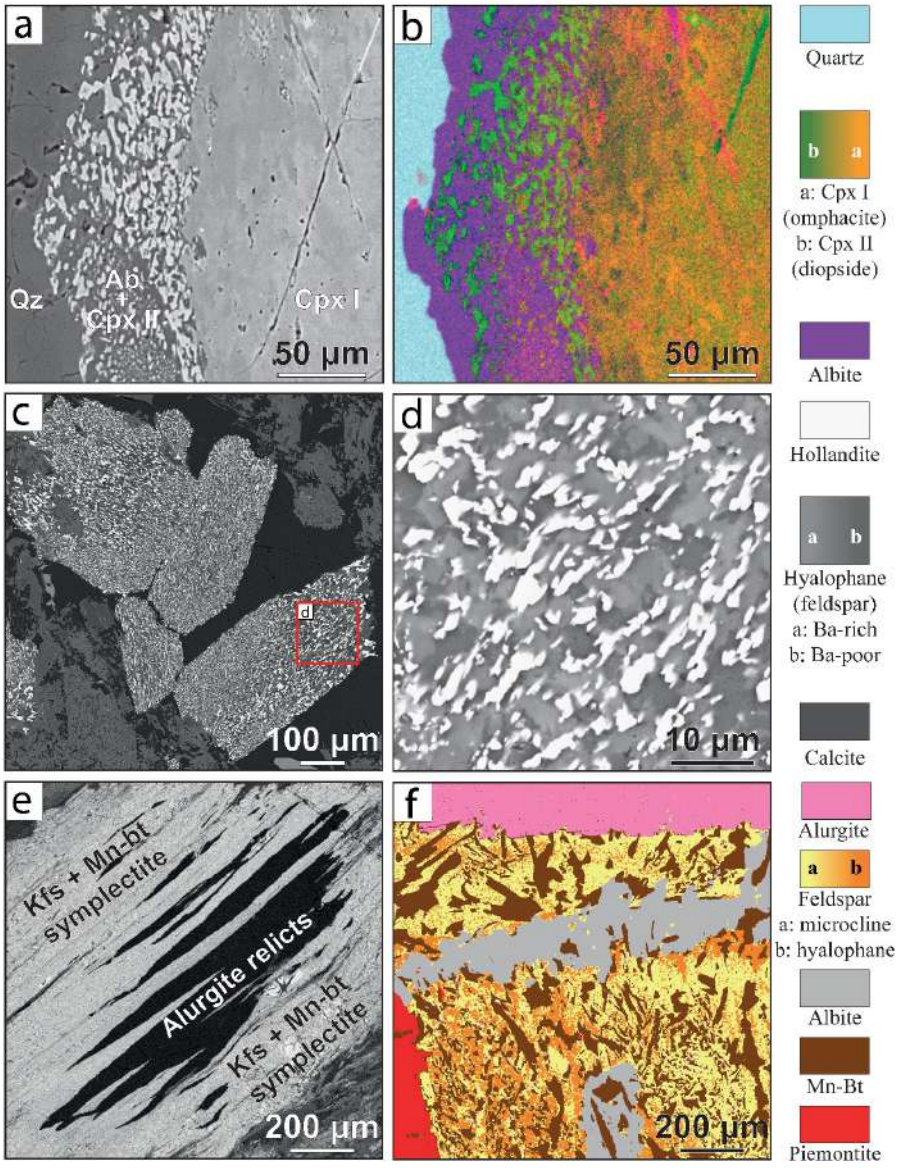

Figure 5.7. Symplectites after omphacite (a, b), piemontite (c, d) and alurgite (e, f). Images generated from backscattered electrons (a, c-e) and elemental maps (b, f).

Level 3, minor phases like hematite and uncommon vanadates (wakefieldite) can also be produced[13].

The piemontite in Level 1 veins partly broke down to form a symplectite consisting of hollandite + hyalophane + Sr-rich calcite (Fig. 5.7c, d), which suggests an increase in CO_2 activity. Conversely, when CO_2 was less available, preventing carbonate formation, the products were hematite + quartz + albite + clinopyroxene + amphibole ± titanite, like in Level 2[14]. The presence of albite and titanite in the symplectite confirms that it formed during a drop in pressure.

The Mn-rich purple mica alurgite was also partly replaced by a symplectite consisting of a Ba-rich K-feldspar (hyalophane) and a Mn-rich phlogopite (manganophyllite)[15], due to the retrograde destabilisation of the alurgite (Fig. 5.7e, f).

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[13] S. Tumiati, M. Merlini, G. Godard, M. Hanfland, P. Fumagalli, *Orthovanadate wakefieldite-(Ce) in symplectites replacing vanadium-bearing omphacite in the ultra-oxidized manganese deposit of Praborna (Aosta Valley, Western Italian Alps)*, in «American Mineralogist», vol. 105, 2020, pp. 1242-1253.

[14] S. Tumiati, *Geochemistry, mineralogy and petrology of the eclogitized manganese deposit of Praborna (Valle d'Aosta, Western Italian Alps)*, cit.

[15] S. Martin-Vernizzi, *La mine de Praborna (Val d'Aoste, Italie): une série manganésifère métamorphisée dans le faciès éclogite*, cit.; S. Tumiati, *Geochemistry, mineralogy and petrology of the eclogitized manganese deposit of Praborna (Valle d'Aosta, Western Italian Alps)*, cit.

Chapter 6

Mineralogy

Having examined the geological and petrological features of Praborna, we can now turn our attention to its minerals. Praborna is internationally renowned not only because of its historical importance, but also for the extraordinary variety of minerals preserved within its rocks. The International Mineralogical Association (IMA) recognises Praborna as the type locality of several valid mineral species, which in principle means that they were first described here. These include piemontite and manganiandrosite-(Ce), which belong to the epidote group, as well as the oxides braunite and strontiomelane. Praborna is also the first recorded locality of various mineral species or varieties that are no longer recognised by the IMA. These include violan (a violet-blue variety of omphacite and diopside), alurgite (a purple Mn-bearing mica), greenovite (a pink titanite) and romeite (now a group of minerals belonging to the pyrochlore supergroup). Many other unusual minerals occur here and in the similar Varenche deposit (Saint-Barthélemy, Nus)[1], some with striking colours and some with peculiar chemical compositions. In this chapter, we explore the main mineral groups and explain what makes Praborna unique.

6.1 Oxides and hydroxides

6.1.1 Manganese oxyhydroxides

Manganese oxides, particularly braunite, are abundant in the massive basal layers 1 and 2, which are typically several metres thick. These oxides form the backbone of Praborna's ore, which has been mined for centuries. Consequently, much of it has now been removed, leaving cavities. The same manganese oxides are also present as accessory minerals in other levels of the lithological sequence.

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https://doi.org/10.14672/QUAD2026-47-6

[1] Barresi *et al.* drew up the inventory of minerals from Varenche: A.A. Barresi, U. Kolitsch, M.E. Ciriotti, P. Ambrino, R. Bracco, E. Bonacina, *La miniera di manganese di Varenche (Aosta, Italia nord-occidentale): Ardennite, arsenioplеite, manganberzelite, pirofanite, sarkinite, sursassite, thortveitite, nuovo As-Sc analogo della metavariscite e altre specie*, in «Micro», 2005, pp. 81-122.

Figure 6.1. Cabochons cut from semiprecious minerals found in the Praborna mine.

Top row (*from left to right*): Mn-rich garnet; violan; rhodonite. Middle row: subhedral «greenovite» within a quartz-rich matrix; piemontite (+ alurgite). Bottom row: spessartine (yellow) and rhodonite (pink); violan (violet) surrounded by an irregular «schefferite» corona (brown) in a quartz (white) and braunite (black) matrix; aegirine-augite.

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Before the 19th century, glassmakers and scholars, such as H.-B. de Saussure, referred to the Praborna ore as «*manganese*» in Italian, «*manganèse noir*» in French or «*magnesia nigra*» in Latin. At the same time, German authors described similar ores as «*braunstein*» (brown stone). A dozen studies devoted to the mineralogy of manganese oxides were published at the beginning of the 19th century, and several mineral species were identified, one of which crystallises in the form of octahedra. In 1831, the Scotsman William Haidinger, possibly influenced by the German word «*braunstein*», named it «braunite» reportedly in honour of Cammerath Braun of Gotha (probably Wilhelm von Braun)[2]. However, in 1832, François Sulpice Beudant named the mineral from Praborna «marceline» after the village of Saint-Marcel, where it was found[3]. He believed that marceline was distinct from Haidinger's braunite due to its relatively high silica content and slightly different octahedral crystal shape. August Breithaupt added to the confusion by proposing the name «heterokline», seemingly in reference to the octahedron's slightly variable angle between faces[4]. However, Alexis Damour and, later, Armand Dufrénoy demonstrated that the differences between marceline, braunite and heterokline were unfounded[5]. Beudant's marceline appeared to have a high silica content because it was mixed with quartz, whereas Haidinger's braunite also contained some silica. As for the shape of the crystals, the difference was likely due to inaccuracies in goniometric measurements. Thus, the name braunite, which predates marceline by a year, prevailed. Nevertheless, the Praborna deposit is still considered one of the type localities for this mineral species.

Braunite ($Mn^{2+}Mn^{3+}{}_6(SiO_4)O_8$) is a peculiar oxide of tetragonal symmetry (Fig. 6.2), which can contain high amounts of CaO and Fe_2O_3, as well as up to 10 wt.% SiO_2, meaning that it is also considered a silicate. Occurring alongside rhodochrosite, amphibole, garnet and piemontite, black-coloured braunite often forms euhedral octahedral crystals and displays a mosaic microstructure under an optical microscope. First-generation braunite crystals may be rimed by a second-generation braunite enriched in Fe, Ca and Ti, with a concomitant decrease

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[2] W. Haidinger, *Mineralogical Account of the Ores of Manganese*, in «Transactions of the Royal Society of Edinburgh», vol. 11, 1831, pp. 119-142 + pl. VII.

[3] F.S. Beudant, *Traité élémentaire de minéralogie*, 2ème édition, Verdière, Paris 1830-1832, 2 vols. [vol. 2, pp. 188-190].

[4] A. Breithaupt in A. Dufrénoy, *Traité de Minéralogie*, Carilian-Goeury et V. Dalmont, Paris 1844-1847, 3 vol. + atlas [vol. III, pp. 764-765].

[5] A. Damour, *Analyses de la marceline*, in «Annales des Mines», (4ème sér.) vol. 1, 1842, pp. 400-408; A. Dufrénoy, *Traité de Minéralogie*, cit.

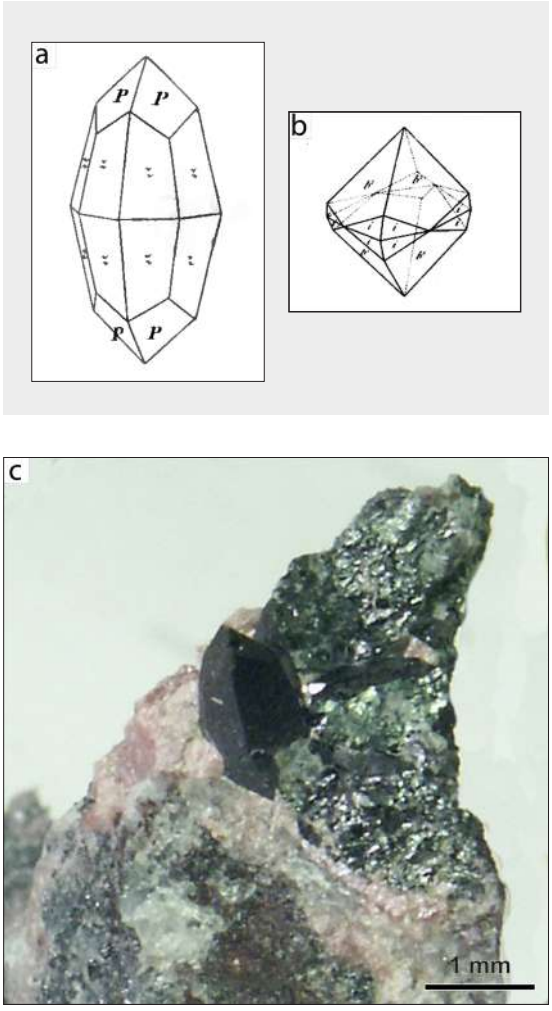

Figure 6.2. Braunite from Praborna.

(a) A braunite crystal from Praborna, by W. Haidinger, *Mineralogical Account of the Ores of Manganese*, in «Transactions of the Royal Society of Edinburgh», vol. 11, 1831, (pl. VII, fig. 22).

(b) Another crystal by A. Dufrénoy, *Traité de Minéralogie, 1844-1847* (vol. IV, pl. 54, fig. 14); Haidinger's crystal faces z are more developed, but are equivalent to Dufrénoy's truncations i; the symmetry is tetragonal in both cases.

(c) Braunite is usually found in a massive form at Praborna, but here it forms a nice, black, mm-sized crystal, which is similar to that shown in (a).

in Mn, suggesting the occurrence of solid solutions with isomorphous braunite-II ($Ca(Mn^{3+},Fe^{3+})_{14}(SiO_4)O_{20}$) and neltnerite ($CaMn^{3+}_6(SiO_4)O_8$)[6]. Braunite is commonly associated with hausmannite ($Mn^{2+}Mn^{3+}_2O_4$), in which Mn^{2+} can be replaced by Zn^{2+}, Fe^{2+} and Mg^{2+}. Manganiferous spinel, jacobsite, has been observed in the quartz-free sample studied by Cenki-Tok and Chopin[7].

Where fluid circulation has been active during the retrograde evolution, braunite and accessorily hausmannite have been transformed into hydrated pyrolusite and/or cryptomelane. Pyrolusite ($Mn^{4+}O_2 \pm H_2O$) is characterised by the oxidation of manganese to Mn^{4+} and the presence of up to 2 wt.% H_2O; it may also contain some Ba and K. Cryptomelane belongs to an isostructural series with the general formula ($X\,Mn^{2+}_2Mn^{4+}_6O_{16}$), the end-members of which are cryptomelane (X = K), hollandite (X = Ba) and strontiomelane (X = Sr). These minerals can be hydrated as they incorporate some OH anions into their structure; manganese can also be partially substituted by Cu, Zn, Co, Ni or Fe. Visually indistinguishable from cryptomelane, hollandite ($Ba(Mn^{4+}_6Mn^{3+}_2)O_{16}$) has been found in the form of rare, black, metallic crystals with a pseudocubic habit, measuring up to 1 cm[8]. It also occurs as secondary μm-sized crystals in symplectites after piemontite (see Section 5.3.3). Finally, strontiomelane ($Sr(Mn^{4+}_6Mn^{3+}_2)O_{16}$) has been discovered at Praborna, which is the type locality of this mineral species[9]. Priderite ($(K, Ba, Sr)(Ti^{4+}_7Fe^{3+})O_{16}$, which is isostructural with the cryptomelane series, has been observed as inclusions within piemontite[10]. Another hydrated mineral found in these quartzites, most-

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[6] S. Martin-Vernizzi, *La mine de Praborna (Val d'Aoste, Italie): une série manganésifère métamorphisée dans le faciès éclogite*, cit.; A. Mottana, *Blueschist-facies metamorphism of manganiferous cherts: a review of the alpine occurrences*, cit.

[7] B. Cenki-Tok, C. Chopin, *Coexisting calderite and spessartine garnets in eclogite-facies metacherts of the Western Alps*, cit.

[8] P. Brown, E.J. Essene, D.R. Peacor, *The mineralogy and petrology of manganese-rich rocks from St. Marcel, Piedmont, Italy*, in «Contributions to Mineralogy and Petrology», vol. 67 (3), 1978, pp. 227-232; P. Ambrino, P. Brizio, *Miniera di Prabornaz, Saint-Marcel, Valle d'Aosta, Italia*, in «Macro Micro», vol. 8, 2007, pp. 3-12.

[9] E.-A. Perseil, *Evolution cristallochimique des oxydes de manganèse dans le gisement de St. Marcel-Praborna (V. Aoste, Italie)*, in «Rendiconti Lincei – Scienze Fisiche e Naturali», (ser. 9) vol. 9, 1998, pp. 315-336; N. Meisser, E.-A. Perseil, J. Brugger, P.-J. Chiappero, *Strontiomelane, $SrMn^{4+}_6Mn^{3+}_2O_{16}$, a new mineral species of the cryptomelane group from St. Marcel-Praborna, Aosta Valley, Italy*, in «The Canadian Mineralogist», vol. 37 (3), 1999, pp. 673-678.

[10] E.-A. Perseil, *La présence de Sb-rutile dans les concentrations manganésifères de St. Marcel – Praborna (Val d'Aoste, Italie)*, in «Schweizerische Mineralogische und Petrographische Mitteilungen», vol. 71 (3), 1991, pp. 341-347.

ly in veins, is manganite (MnO(OH)), which is often associated with hausmannite. Under cross-polarised light, manganite is characterised by internal red reflections, whereas hausmannite is easily identificable due to the presence of twinning. Birnessite ($(Na, Ca)_{0.5}(Mn^{4+}, Mn^{3+})_2O_4 \cdot 1.5H_2O$) has also been reported at Praborna[11].

6.1.2 Ti and Fe oxides

Rutile (ideally TiO_2) is present at Praborna as an accessory mineral in levels 1 to 4 of the lithological sequence. Sub-millimetre-sized crystals of rutile, formed under eclogite-facies metamorphism, are typically encircled by coronas of titanite (Fig. 6.3b), which grew during subsequent retrogression. As noted by Smith and Perseil (1997) and Tumiati (2005), rutile at Praborna can contain up to 0.2 moles of Sb[12]. These authors suggest that Sb^{5+} could replace Ti^{4+} via the substitution $2\ Ti^{4+} = 1\ R^{3+} + 1\ Sb^{5+}$, where R^{3+} cations are, in order of importance, $Fe^{3+} >> Mn^{3+} > Cr^{3+} \approx Al^{3+}$. Sb-rich rutile commonly surrounds Sb-free rutile within the same crystal (Fig. 6.3a), which could be due to either Sb metasomatism affecting pre-existing rutile or to the growth of neoblastic Sb-rich rutile.

Pyrophanite, with an ideal formula of $Mn^{2+}Ti^{4+}O_3$, is isostructural of ilmenite ($Fe^{2+}Ti^{4+}O_3$). At Praborna, this mineral occurs in the upper, garnet-rich levels of the lithological sequence[13]. It is slightly enriched in Sb, similarly to rutile and titanite.

Although it is an accessory mineral, hematite (ideally Fe_2O_3) is common at Praborna. It occurs as μm-sized inclusions trapped in garnet and piemontite during prograde metamorphism, as well-formed accessory crystals in some high-pressure parageneses and as late μm-sized by-products of omphacite and piemontite breakdowns. It can incorporate some Cr, Ti and Mn, and its composition varies slightly depending on the setting. Hematite with the highest Cr

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[11] D.C. Smith, E.-A. Perseil, *Sb-rich rutile in the manganese concentrations at St. Marcel-Praborna, Aosta Valley, Italy: petrology and crystal-chemistry*, in «Mineralogical Magazine», vol. 61, 1997, pp. 655-669.

[12] E.-A. Perseil, *La présence de Sb-rutile dans les concentrations manganésifères de St. Marcel – Praborna (Val d'Aoste, Italie)*, cit.; D.C. Smith, E.-A. Perseil, *Sb-rich rutile in the manganese concentrations at St. Marcel-Praborna, Aosta Valley, Italy: petrology and crystal-chemistry*, cit.; S. Tumiati, *Geochemistry, mineralogy and petrology of the eclogitized manganese deposit of Praborna (Valle d'Aosta, Western Italian Alps)*, cit.

[13] S. Tumiati, *Geochemistry, mineralogy and petrology of the eclogitized manganese deposit of Praborna (Valle d'Aosta, Western Italian Alps)*, cit.

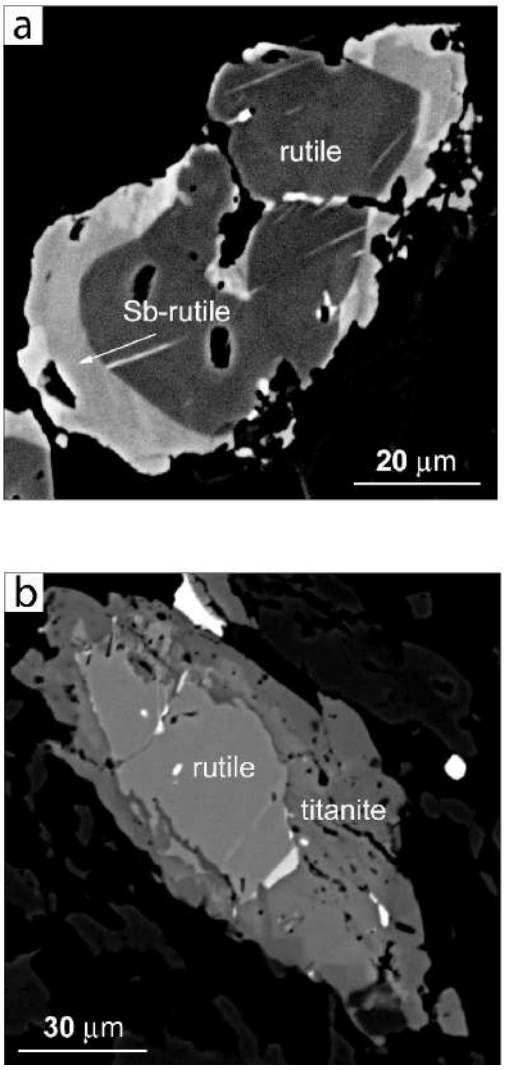

Figure 6.3. Rutile microcrystals.

(a) A rutile microcrystal showing an Sb-rich overgrowth.

(b) A rutile crystal surrounded by a corona of titanite (backscattered electron images).

and Ti contents is found in Cr-rich Level 3 (0.149 and 0.018 atoms per formula unit, respectively), whereas the highest Mn content occurs in Level 6 (up to 0.028 Mn/(Mn+Fe)), where hematite coexists with pyrophanite ($MnTiO_3$)[14].

6.1.3 Roméite

Roméite ($Ca_2Sb_2O_6(O, OH, F)$), also known as roméine, belongs to the pyrochlore supergroup of minerals, which have the general formula $A_{2-m}D_2O_{6-w}Z_{1-n}$, where D is Sb^{5+} in the case of roméite. This extremely rare mineral is found in metamorphic Fe-Mn-rich deposits and in hydrothermal veins.

Roméite was discovered at Praborna in 1840 by Jean-Pierre Bertrand de Lom, who proposed naming it «albertine», in honour of King Carlo-Alberto of Piedmont-Sardinia[15]. Having been entrusted by Bertrand de Lom with the task of studying his samples, Alexis Damour described the mineral in 1841 and named it «roméine» in honour of the French mineralogist Romé de l'Isle[16]. Due to goniometric measurements made by Dufrénoy in 1841[17], the mineral was long considered to be tetragonal, but Alberto Pelloux demonstrated in 1914 that its octahedral shapes and angles were virtually identical to those of the isometric (i.e., cubic) octahedron[18]. Although the Praborna roméite was originally described as $CaSb^{3+}{}_2O_4$ by Damour[19], Schaller determined a

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[14] S. Tumiati, *Geochemistry, mineralogy and petrology of the eclogitized manganese deposit of Praborna (Valle d'Aosta, Western Italian Alps)*, cit.

[15] 7/6/1840, *Description minéralogique et géognostique du dépot de minerai de manganèse du haut de la combe de St. Marcel, vallée d'Aosta, Piémont [par Bertrand de Lom]*, FD 11 J 423; J.P. Bertrand de Lom, *Note sur la roméine*, in «Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences [de Paris]», vol. LXII, 1866, p. 144.

[16] A. Damour, *Sur la roméine, nouvelle espèce minérale, de Saint-Marcel en Piémont*, in «Annales des Mines», (3ème sér.) vol. 20, 1841, pp. 247-254; A. Damour, *Sur la Roméine, nouvelle espèce minérale*, in «Echo du Monde savant», 8ème année, 1841, n° 661, 1er septembre 1841, p. 506; n° 676, 27 octobre 1841, pp. 628-629.

[17] Dufrénoy in A. Damour, *Sur la roméine, nouvelle espèce minérale, de Saint-Marcel en Piémont*, cit.

[18] A. Pelloux, *Nuove forme della romeina di S. Marcel in Valle d'Aosta*, cit.; A. Pelloux, *Nuove forme della romeina di S. Marcel in Valle d'Aosta*, in «Annali del Museo civico di storia naturale di Genova», (Ser. 3) vol. VI, 1914, pp. 22-24.

[19] A. Damour, *Nouvelles recherches sur la composition de la roméine, especе minérale*, in «Annales des Mines», (5ème sér.) vol. 3, 1853, pp. 179-184.

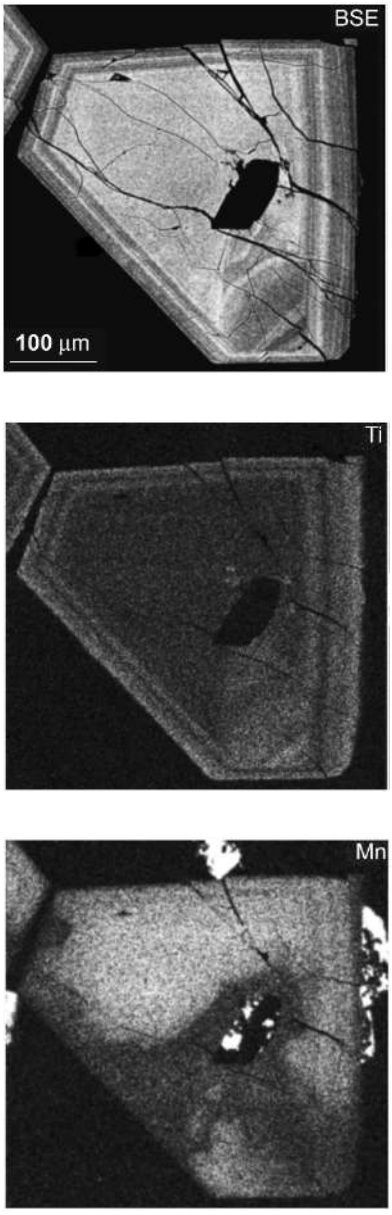

Figure 6.4. Roméite microcrystal.

Oscillatory zoning is clearly visible at the edges of the crystal in the backscattered electron image, as well as in the Ti and Mn element maps.

pentavalent oxidation state of Sb in 1916[20]. In 1932, after demonstrating that roméite is isostructural with clinochlore, Otto Zedlitz[21] described Praborna roméite with a chemical formula of ((Ca, Na, Mn)$_2$ Sb$^{5+}_2$ (O, OH, F)$_7$), which is close to the presently accepted composition. In 1997, Brugger *et al.* published a detailed study of the crystal chemistry of roméite from Praborna and other locations[22]. Following a 2010 revision of the nomenclature by the IMA, roméite is now considered to be a series between two isometric end-members, namely oxyplumboroméite ($Pb_2Sb^{5+}_2O_6O$) and fluorcalcioroméite (($(Ca, Na, \square)_2Sb^{5+}_2(O, OH)_6F$), the Praborna roméite being close to the last one.

Nowadays, roméite is extremely rare at Praborna. A sample stored at the *Museum National d'Histoire Naturelle* in Paris contains sub-millimetre-sized euhedral crystals of roméite alongside Sr-bearing piemontite, As-bearing apatite and braunite, within a matrix of quartz, microcline and albite[23]. The mean composition of roméite, obtained by averaging 275 spot analyses using an electron microprobe, is $(Ca_{1.29}\ Y_{0.13}\ Mn^{2+}_{0.10}\ Na_{0.09}\ Fe^{2+}_{0.02}\ REE_{0.01}\ Sr_{0.01})_{\Sigma=1.7}$ $(Sb^{5+}_{1.93}\ Ti_{0.06}\ As^{5+}_{0.01}\ Sn^{4+}_{0.01})_{\Sigma=2.00}\ (O, OH)_{6.59}\ F_{0.30}$. Roméite crystals are generally highly zoned, with oscillatory zoning visible at their rims (Fig. 6.4). The main variations occur among Ti, Sb^{5+} and Na, probably via the substitution $Sb^{5+} \rightarrow 1\ Ti^{4+} + 1\ Na^{+}$. Another important substitution is $Ca^{2+} \rightarrow Mn^{2+}$ in the *A* site. Yttrium, which is unusually abundant in Praborna roméite, is correlated with Sb, whereas F is correlated with Na and Ti.

6.2 Silicates

Silicates are by far the most abundant minerals at Praborna. Apart from the ubiquitous quartz, they are typically minerals with unusual compositions that have incorporated manganese and/or trace elements. Here, we present an inventory of these silicates, which is unavoidably incomplete, classified by groups.

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[20] W.T. Schaller, *Mineralogic Notes, series 3: Romeite*, in «United States Geological Survey, Bulletin», vol. 610, 1916, pp. 95-103 + Fig. A in pl. IV.

[21] O. Zedlitz, *Die Kristallstrukturen von Romeit und Schneebergit*, in «Zeitschrift für Kristallographie», vol. 81, 1932, pp. 253-263.

[22] J. Brugger, R. Gieré, S. Greaser, N. Meisser, *The crystal chemistry of roméite*, in «Contributions to Mineralogy and Petrology», vol. 127 (1-2), 1997, pp. 136-146.

[23] S. Tumiati, *Geochemistry, mineralogy and petrology of the eclogitized manganese deposit of Praborna (Valle d'Aosta, Western Italian Alps)*, cit.

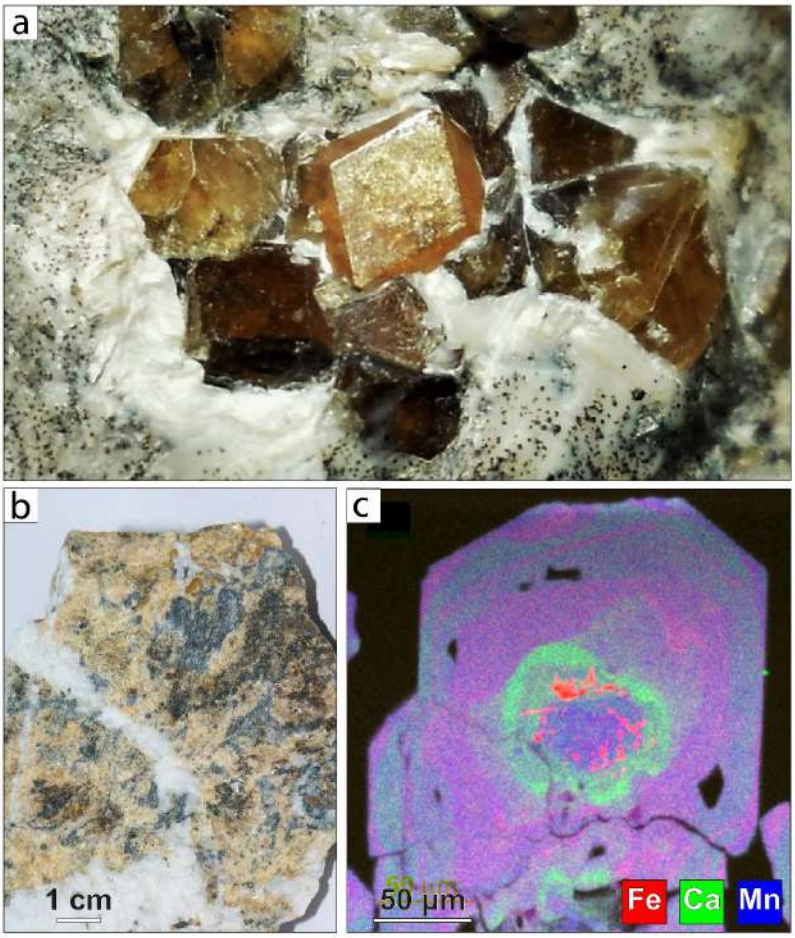

Figure 6.5. Garnet in Level 4 of Praborna.

(a) Idiomorphic spessartine crystals in a quartz matrix.

(b) Hand specimen showing garnet (yellow), quartz (white), braunite and amphibole (black).

(c) Section of a manganiferous garnet crystal from Level 4 exhibiting complex zoning and hematite inclusions in its core (RGB image combining Fe, Ca and Mn maps obtained by energy-dispersive X-ray spectrometry at the scanning electron microscope).

(a) © Raffaele Prete.

6.2.1 Garnets

Garnets are among the most distinctive minerals found in Praborna. They are usually Mn-rich, dominated by spessartine ($Mn^{2+}_3Al^{3+}_2Si_3O_{12}$). However, other end-members commonly occur as solid solutions, including grossular (Ca-rich), andradite (Fe^{3+}-rich), calderite ($Mn^{2+}_3Fe^{3+}_2Si_3O_{12}$), pyrope (Mg-rich), and even the Cr-bearing uvarovite ($Ca^{2+}_3Cr^{3+}_2Si_3O_{12}$). The rare henritermierite end-member ($Ca_3Mn^{3+}_2[(SiO_4)_2(OH)_4]$) has also been reported in some garnets.

Garnets have been described in Praborna since the 18th century, but it was advances in chemistry and mineralogy that led to the identification of manganiferous garnets. Barelli first described these in 1835 under the name «colophonite», referring to their «yellow colour like apples»[24]. In 1910, Colomba identified a green garnet rich in uvarovite (26 mol%)[25], most likely from the Cr-rich Level 3. Modern analytical tools, such as electron microprobes, have enabled this inventory to be expanded, notably with the discovery of garnets rich in the calderite end-member[26].

Many garnet crystals exhibit zoning, with Mn-rich cores surrounded by rims enriched in either Ca or Fe (Fig. 6.5c). This zoning reflects chemical changes during burial and fluid circulation. For example, calderite-rich garnets are found alongside Mn-carbonates, pyroxmangite and hematite, pointing to localised Ca–Mn–Fe-rich microdomains. The diversity of garnets at Praborna makes them excellent indicators of the redox state and geochemical environment.

6.2.2 Clinopyroxenes

Praborna is world-famous for violan, a violet-blue variety of omphacite that remains one of the mine's symbols. Violan is strikingly beautiful, and was once cut as a semiprecious stone (Fig. 6.6a, b). However, it is even more valuable from a scientific perspective, as its Mn-bearing composition reflects the unusual chemistry of the deposit. Other abundant clinopyroxenes include

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[24] V. Barelli, *Cenni di statistica mineralogica degli stati di S. M. il Re di Sardegna ovvero Catalogo Ragionato della Raccolta formatasi presso l'Azienda Generale dell'Interno*, Giuseppe Fodratti, Torino 1835, 687 pp.

[25] L. Colomba, *Sopra un granato ferri-cromifero di Praborna (S. Marcel)*, in «Atti della R. Accademia dei Lincei. Rendiconti. Classe di Scienze fisiche, matematiche e naturali», (ser. V) vol. XIX (2° sem.), 1910, pp. 146-150.

[26] B. Cenki-Tok, C. Chopin, *Coexisting calderite and spessartine garnets in eclogite-facies metacherts of the Western Alps*, cit.

omphacite, aegirine-jadeite**,** aegirine-augite**,** Mn-bearing diopsides, «schefferite» and chloromelanite.

Horace-Bénédict de Saussure certainly observed the violan at Praborna in August 1792[27], as evidenced by sample n° 1270 in his collection (Fig. 4.3d). August Breithaupt coined the name «violan» in 1838[28], but did not identify it as a pyroxene. This was achieved by Alfred Des Cloizeaux (1867, 1874) and Emil Schluttig (1884)[29], who classified the mineral based on its optical properties and chemical composition. Since the 1970s, crystallographic and chemical characterisations of violan and other clinopyroxenes from Praborna have been carried out using modern investigative techniques[30].

These clinopyroxenes are more or less sodic, being rich in aegirine or jadeite end-members, with the latter reflecting the high-pressure conditions in which they formed. Their colour commonly depends on minor elements. For instance, the violet-blue hue of the Mn-bearing «violan» variety has a complex origin, since omphacites enriched in Ti and Li exhibit a dark violet colour, while diopside pyroxenes, with a higher content of V and REEs vary in colour from lilac-lavender to light-violet-blue[31]. Clinopyroxene is brownish if

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[27] H.-B. de Saussure, *Voyages dans les Alpes*, cit.

[28] A. Breithaupt, *Bestimmung neuer Mineralien*, in «Journal für praktische Chemie», vol. 15, 1838, pp. 320-338 [pp. 329-330].

[29] A. Des Cloizeaux, *Manuel de Minéralogie*, Dunod, Paris 1862-1874, 3 vol. [violan: vol. 1, pp. 66-67; vol. 2: pp. XIX-XX]; Id., *Nouvelles recherches sur les propriétés optiques des cristaux naturels ou artificiels, et sur les variations que ces propriétés éprouvent sous l'influence de la chaleur*, Extrait des «Mémoires présentés par divers savants à l'Institut impérial de France», t. XVIII, Impr. impériale, Paris 1867, in-4°, 222 pp. [violan: pp. 183-184]; E. Schluttig, *Chemisch-mineralogische Untersuchungen von weniger bekannten Silicaten, Inaugural-Dissertation zur Erlangung der Doctorwürde einer Hohen Philosophischen Facultät der Universität Leipzig*, G. Reichardt, Groitzsch 1884 [Violan: pp. 17-22].

[30] M. Bondi, A. Mottana, G. Kurat, G. Rossi, *Cristallochimica del violano e della schefferite di St. Marcel (Valle d'Aosta)*, in «Rendiconti della Società Italiana di Mineralogia e Petrologia», vol. 34 (1), 1978, pp. 15-25; A. Mottana, G. Rossi, A. Kracher, G. Kurat, *Violan revisited: Mn-bearing omphacite and diopside; Violan, ein Mn-führender Omphacit und Diopsid*, in «Tschermaks mineralogische und petrographische Mitteilungen», vol. 26, 1979, pp. 187-201; W.L. Griffin, A. Mottana, *Crystal chemistry of clinopyroxenes from the St. Marcel manganese deposit, Val d'Aosta, Italy*, in «American Mineralogist», vol. 67, 1982, pp. 568-586; J.-R. Kiénast, S. Martin, *I pirosseni egirin-giadeitici del livello basale di Praborna, Alpi occidentali*, in «Ofioliti», vol. 8 (2), 1983, pp. 245-260; S. Tumiati, *Geochemistry, mineralogy and petrology of the eclogitized manganese deposit of Praborna (Valle d'Aosta, Western Italian Alps)*, cit.

[31] V. Diella, R. Bocchio, F. Caucia, N. Marinoni, A. Langone, E. Possenti, *New insights for gem-quality Mn-bearing diopside-omphacite, violane variety, from Saint Marcel (Val D'Aosta,*

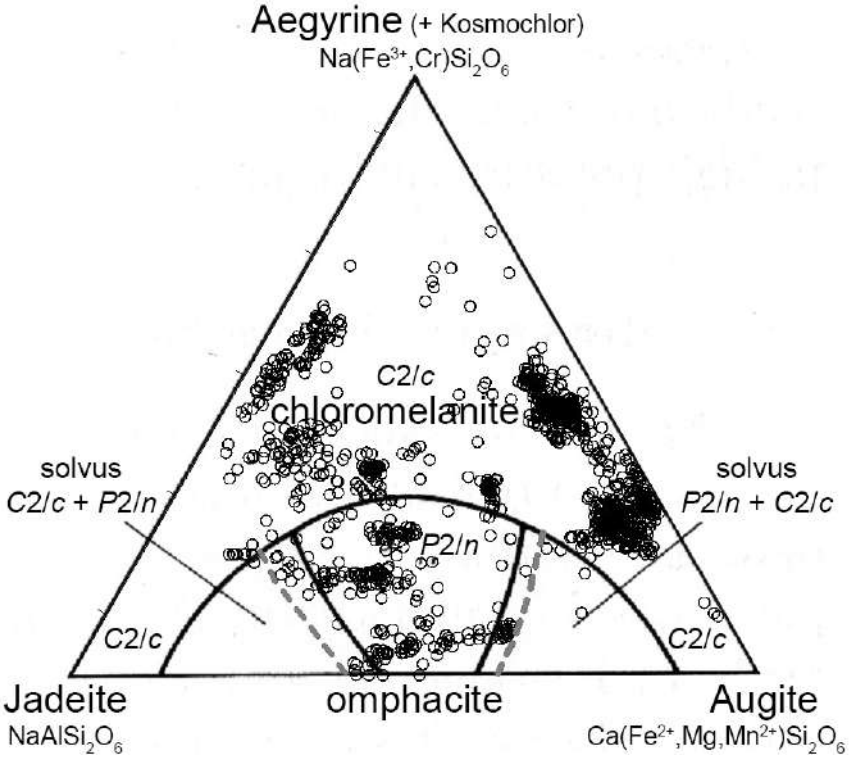

Figure 6.7. Heterogeneous composition of the Praborna clinopyroxenes.

Microprobe data are compiled from Griffin and Mottana (1982), Martin-Vernizzi (1982) and Tumiati (2005).

Evidence for two solvi is provided by the miscibility gaps that occur between jadeite and omphacite, and between omphacite and diopside.

it contains some Mn^{2+} («schefferite» variety), emerald-green if Cr^{3+} substitutes Al^{3+} (in Level 3: Fig. 6.6c) and dark green if it is rich in the aegirine end-member. The jadeite content varies considerably, and this heterogeneity has been in part attributed to the presence of two miscibility gaps in the jadeite-diopside solid solution (Fig. 6.7)[32]. In 1988, when it became clear that the violet «violan» could be either omphacite or diopside, sometimes in equilibrium with each other, it could no longer be considered a species, but rather an *ex-colore* variety of clinopyroxene[33].

6.2.3 Pyroxenoids

Closely related to pyroxenes are the pyroxenoids, which differ only in the periodicity of their silicate chains. At Praborna, they are represented by pink rhodonite ($MnSiO_3$) and its high-pressure polymorph pyroxmangite. Rhodonite was first recognised at Praborna by Dufrénoy and Ébelmen in the 1840s, and was further studied by Colomba (1903-1904) and Rondolino (1934)[34], whereas pyroxmangite was described more recently[35].

Pyroxmangite is particularly significant because it only remains stable under the high pressures found in subduction zones. At Praborna, it occurs in both massive ore and veins, and is commonly associated with spessartine gar-

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Italy): Its trace elements and spectroscopic characterization, in «Minerals», vol. 11, 2021, n° 171 (21 pp.).

[32] M. Bondi, A. Mottana, G. Kurat, G. Rossi, *Cristallochimica del violano e della schefferite di St. Marcel (Valle d'Aosta)*, cit.; A. Mottana, G. Rossi, A. Kracher, G. Kurat, *Violan revisited: Mn-bearing omphacite and diopside; Violan, ein Mn-führender Omphacit und Diopsid*, cit.; W.L. Griffin, A. Mottana, *Crystal chemistry of clinopyroxenes from the St. Marcel manganese deposit, Val d'Aosta, Italy*, cit.; J.-R. Kiénast, S. Martin, *I pirosseni egirin-giadeitici del livello basale di Praborna, Alpi occidentali*, in «Ofioliti», vol. 8 (2), 1983, pp. 245-260.

[33] N. Morimoto, J. Fabries, A.K. Ferguson, I.V. Ginzburg, M. Ross, F.A. Seifert, J. Zussman, K. Aoki, G. Gottardi, *Nomenclature of Pyroxenes*, in «American Mineralogist», vol. 73 (9-10), 1988, pp. 1123-1133.

[34] A. Dufrénoy, *Traité de Minéralogie*, Carilian-Goeury et V. Dalmont, Paris 1844-1847, 3 vol. + atlas [rhodonite: vol. II, pp. 428-433]; J.-J. Ébelmen, *Recherches sur les produits de la décomposition des espèces minérales de la famille des silicates*, in «Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences [de Paris]», vol. XX, 1845, pp. 1415-1423; L. Colomba, *Rodonite cristallizzata di S. Marcel (Valle d'Aosta)*, in «Atti della R. Accademia delle Scienze di Torino», vol. 39, 1903-1904, pp. 664-668; R. Rondolino, *Sopra alcuni minerali di St. Marcel (Valle d'Aosta)*, in «Periodico di Mineralogia», vol. 5 (2), 1934, pp. 123-139 + Tav. V.

[35] S. Martin-Vernizzi, *La mine de Praborna (Val d'Aoste, Italie): une série manganésifère métamorphisée dans le faciès éclogite*, cit.; S. Tumiati, *Geochemistry, mineralogy and petrology of the eclogitized manganese deposit of Praborna (Valle d'Aosta, Western Italian Alps)*, cit.

net and Mn-amphiboles. Rhodonite, on the other hand, gives many samples a brilliant pink colour, making it one of the Praborna's most visually striking minerals. It occurs as either translucent, pink or orange-red crystals measuring a few millimetres, or as compact, opaque, pink masses (Fig. 6.8).

6.2.4 Amphiboles

Amphiboles are double-chain silicates, capable of hosting many elements. At Praborna, they occur in the form of unusual Mn-rich minerals such as Manganocummingtonite**,** Mn-bearing tremolite**,** K-richterite, edenite and winchite.

Fibrous amphiboles have been observed at Praborna for a long time. For example, Jean-Laurent Martinet mentioned some «*actinote fibreuse*» in his 1807 description of the mine[36], and Barelli reported some «tremolite» in 1835[37]. More recently, in 1936, Rondolino provided the first scientific description of Mn-rich «richterite» from Praborna[38], a study followed by those of Martin-Vernizzi (1982), Mottana and Griffin (1986) and many others[39].

At Praborna, amphiboles are frequently found replacing earlier pyroxenes, or in veins cutting across the ore, where they crystallised as white or pink fibres perpendicular to the vein walls (Fig. 6.9). Among these, tremolite and edenite may form bacillary aggregates that can reach several centimetres in length, and range in colour from white-grey to pale purple. These occurrences indicate that amphiboles generally grew during retrograde metamorphism, either in blueschist (e.g., K-richterite) or greenschist facies (e.g., tremolite), when fluids penetrated the rocks during exhumation.

6.2.5 Epidotes

The epidote group is another highlight of Praborna, which is the type locality of piemontite, the reddish-violet, Mn^{3+}-bearing member of the epidote

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[36] ANF F/20/180 pièce 170.

[37] V. Barelli, *Cenni di statistica mineralogica degli stati di S. M. il Re di Sardegna…*, cit.

[38] R. Rondolino, *Sopra alcuni anfiboli manganesiferi di Praborna (San Marcel, Valle d'Aosta)*, in «Periodico di Mineralogia», vol. 7, 1936, pp. 109-121.

[39] S. Martin-Vernizzi, *La mine de Praborna (Val d'Aoste, Italie): une série manganésifère métamorphisée dans le faciès éclogite*, cit.; A. Mottana, W.L. Griffin, *Crystal chemistry of two coexisting K-richterites from St. Marcel (Val d'Aosta, Italy)*, in «American Mineralogist», vol. 71, 1986, pp. 1426-1433.

Figure 6.8. Rhodonite. Rhodonite (pink) occurs here in a braunite-rich matrix (black).

Figure 6.9. Amphibole-bearing vein. A cm-wide vein consisting of quartz, fibrous reddish piemontite and calcic amphibole, elongated subperpendicular to the vein walls (cross-polarised light).

group. The first scholar to write about this mineral appears to have been Axel Fredrik Cronstedt, who named it «*rod Magnesia*», in 1758[40]. In 1788, Napione of Turin analysed it and called it «*Manganèse rouge*». René-Just Haüy, in the first edition of his *Traité de Minéralogie* (1801), designated the substance as «*Manganèse oxidé violet silicifère*»[41]. In 1803, Louis Cordier, on the basis of a new analysis, recognised the mineral as an «*épidote manganésifère*», a name later adopted by Haüy in the second edition of his *Traité* (1822)[42]. It thus became known to English writers as «manganesian epidote» and to German ones as «Manganepidot». The name «*piemontit*» was proposed in 1853 by Kenngott[43], based on the fact that Saint-Marcel was then part of Piedmont, and this name soon replaced the others. For a time, piemontite was thought to be orthorhombic, like zoisite, but it was shown to be monoclinic by Alfred Des Cloizeaux, whose conclusions were confirmed by Hugo Laspeyres and Fausta Balzac[44], who studied the crystallography and optical properties of the mineral (Fig. 4.4).

At Praborna, piemontite is abundant in basal levels 1 and 2, where it commonly fills veins. It can incorporate significant amounts of REEs (Figs. 5.5, 6.10), as well as Sr in substitution of Ca[45]. The amount of Mn^{3+} varies considerably,

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[40] A.F. Cronstedt, *Försök til Mineralogie, eller Mineral-Rikets Upställning [An essay towards a system of mineralogy]*, Tryckt uti Wildiska tryckeriet, Stockholm 1758, 251 pp. [p. 106].

[41] R.J. Haüy, *Traité de minéralogie*, 1ère édition, Louis ed., Paris 1801, 4 vol. + atlas [vol. IV, pp. 168-177].

[42] L. Cordier, *Analyse du minéral connu sous le nom de Mine de Manganèse violet du Piémont, faite au Laboratoire de l'Ecole des Mines*, in «Journal des Mines», 13 (74), 1802-1803 [an XI], pp. 135-142; R.J. Haüy, *Traité de minéralogie*, 2ème édition, Louis ed., Paris 1822, 4 vol. + atlas [vol. II, pp. 575-576].

[43] A. Kenngott, *Das Mohs'sche Mineralsystem dem gegenwärtigen Standpunkte der Wissenschaft gemäss*, Verlag und Druck von Carl Gerold & Sohn, Vienna 1853, 164 + 38 pp. [p. 75].

[44] A. Des Cloizeaux, *Manuel de Minéralogie*, Dunod, Paris 1862-1874, 3 vol. [vol. 1, pp. 254-255]; H. Laspeyres, *Die kristallographischen und optischen Eigenschaffen des Manganepidot (Piemontit)*, in «Zeitschrift für Kristallographie und Mineralogie», vol. IV, 1879, pp. 435-468 + Taf. X-XII; F. Balzac, *Notizie cristallografiche sulla Piemontite di St. Marcel (Valle d'Aosta)*, in «Atti della R. Accademia dei Lincei. Rendiconti. Classe di Scienze fisiche, matematiche e naturali», (ser. 5) vol. 25, 1916, pp. 587-592; F. Balzac, *Kristalografiaj konoj de pedemontito ĉe St. Marcel (Valo de Aosta)*, in «Rivista di Mineralogia e Cristallografia Italiana», vol. 47, 1916, pp. 86-93 [in esperanto].

[45] A. Mottana, W.L. Griffin, *The crystallochemistry of piemontite from the type-locality (St. Marcel, Val d'Aosta, Italy)*, in *Crystal chemistry of minerals; proceedings of the 13th general meeting of the International Mineralogical Association IMA*, Bulgarian Academy of Sciences, Varna, September 19th-25th 1982, 1986, pp. 635-640; E.-A. Perseil, *Particularités*

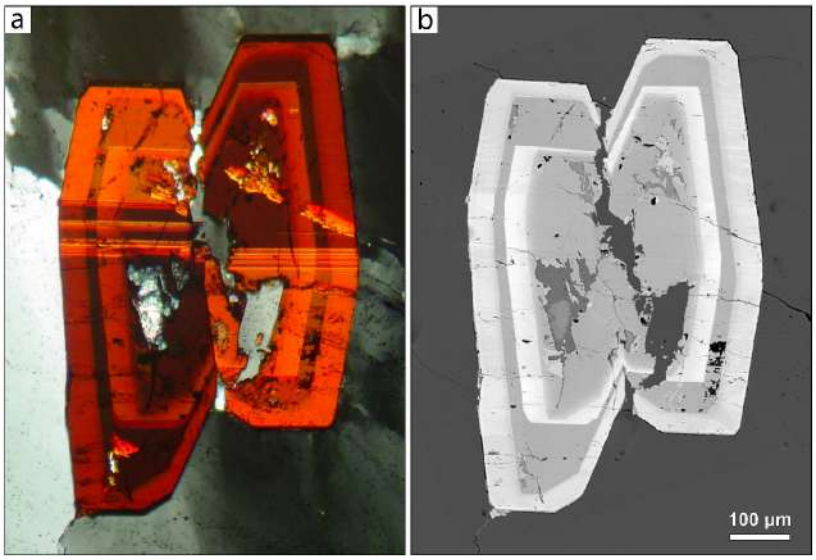

Figure 6.10. Piemontite in a quartz vein of Level 2.

(a) Cross-polarised light; the E-W striations are twins, which Laspeyres described as polysynthetic (see Fig. 4.4); however, they may have at least a partial mechanical origin, given their relationship with the subgrains of the host quartz. (b) Back-scattered electron image; the light and dark concentric growth zones are rich and poor in REEs, respectively.

Figure 6.11. Alurgite.

This copper-red Mn-rich mica is common in Praborna.

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indicating a wide range of solid solution between the piemontite and epidote end-members. Finally, significant amounts of Cr (i.e., the tawmawite end-member) have been reported in the Mn-poor epidote of the Cr-rich Level 3[46].

Another Mn-bearing mineral species of the epidote group has been discovered at Praborna. This is the extremely rare, Ce-rich manganiandrosite-(Ce). It was first described by Cenki-Tok *et al.* (2006)[47] at Praborna, its type locality, where it occurs as transparent grains measuring up to 0.1 mm, which are velvety black or dark brown in colour, with a vitreous-adamantine lustre. In the sample studied by Cenki-Tok *et al*., it occurs as elongated grains associated with tephroite, hematite, calderite and Mn-pyroxenoid (see Section 5.2.8), as well as in the form of isolated grains embedded in a rhodochrosite-pyroxenoid mixture. Bonazzi *et al.* (1996) studied an intermediate term between piemontite and androsite-(La) from the ancient Varenche mine[48].

6.2.6 Micas

Alurgite, a Mn-rich variety of white mica, gives some rocks of Praborna a distinctive purple colour. The presence of Mn^{2+} (ca. 2 wt.% MnO) and the high Si content (up to Si = 3.64 a.f.u.) imply significant phengitic substitution ($Al^{VI} + Al^{IV} \rightarrow (Mn^{2+}, Fe^{2+}, Mg) + Si$), which is consistent with the high-pressure origin of this dioctahedral mica.

In 1865, Breithaupt coined the name alurgite to refer to the purple mica found in Praborna. The name derives from the Greek word ἀλουργός, meaning

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des piémontites de Saint-Marcel-Praborna (Italie); spectres I.R., in «C.R. Congrès nat. des Soc. savantes», vol. 112 (Lyon), 1987, pp. 209-215; M. Catti, G. Ferraris, G. Ivaldi, *Thermal behavior of the crystal structure of strontian piemontite*, in «American Mineralogist», vol. 73, 1988, pp. 1370-1376; M. Catti, G. Ferraris, G. Ivaldi, *On the crystal chemistry of strontian piemontite with some remarks on the nomenclature of the epidote group*, in «Neues Jahrbuch für Mineralogie, Monatshefte», vol. 8, 1989, pp. 357-366.

[46] S. Tumiati, *Geochemistry, mineralogy and petrology of the eclogitized manganese deposit of Praborna (Valle d'Aosta, Western Italian Alps)*, cit.

[47] B. Cenki-Tok, C. Chopin, *Coexisting calderite and spessartine garnets in eclogite-facies metacherts of the Western Alps*, cit.; B. Cenki-Tok, A. Ragu, T. Armbruster, C. Chopin, O. Medenbach, *New Mn-and rare-earth-rich epidote-group minerals in metacherts: manganiandrosite-(Ce) and vanadoandrosite-(Ce)*, cit.

[48] P. Bonazzi, S. Menchetti, T. Reinecke, *Solid solution between piemontite and androsite-(La), a new mineral of the epidote group from Andros Island, Greece*, in «American Mineralogist», vol. 81, 1996, pp. 735-742.

purple shell, although the more common term is πορφύρα[49]. Penfield (1893) then studied the chemistry and optical properties of this mica, recommending that it be considered a distinct species; the mineral was subsequently studied by Meixner and Schaller[50]. In 1998, the IMA mica subcommittee classified it as a variety of Mn-bearing muscovite or illite[51], though most authors consider the alurgite from Praborna to be manganese phengite[52].

Other micas observed in Praborna include Mn-rich phlogopite, particularly in the form of symplectites after alurgite (Fig. 5.7e, f), and a Cr-bearing phengitic mica, fuchsite or mariposite, in the Cr-rich Level 3 (see Section 5.2.4).

6.2.7 Chlorites

Chlorites are widespread retrograde minerals at Praborna, reflecting hydration during exhumation.

In 1910, Colomba reported the presence at Praborna of kämmererite, a variety of clinochlore, presumably in the Cr-rich Level 3, where it would occur alongside uvarovite and native gold[53]. However, kämmererite is purple due to the presence of chromium, whereas the mineral described by Colomba was green, and could actually be the above-mentioned Cr-rich mica.

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[49] A. Breithaupt, *Mineralogische Studien [18. Alurgit (Glimmer); 23. Zoisit. Piemontit]*, in «Berg- und Hüttenmännische Zeitung», vol. XXIV (n° 40, 2 October; n° 41, 9 October), 1865, pp. 335-337, 341-343 [Alurgit: p. 336].

[50] S.L. Penfield, *On some minerals from the manganese mines of St. Marcel, in Piedmont, Italy*, in «American Journal of Sciences», (ser. 3) vol. 46 (274), 1893, pp. 288-295; H. Meixner, *Alurgit und seine Vorkommen: Beziehungen zu Fuchsit und Mariposit*, in «Annalen des Naturhistorischen Museums in Wien», vol. 50, 1939, pp. 694-703; W.T. Schaller, *An interpretation of the composition of high-silica sericites*, in «Mineralogical Magazine», vol. 29 (211), 1950, pp. 405-415.

[51] M. Rieder *et al.*, *Nomenclature of the micas*, in «The Canadian Mineralogist», vol. 36 (3), 1998, pp. 905-912.

[52] W.T. Schaller, *An interpretation of the composition of high-silica sericites*, cit.; P. Brown, E.J. Essene, D.R. Peacor, *The mineralogy and petrology of manganese-rich rocks from St. Marcel, Piedmont, Italy*, in «Contributions to Mineralogy and Petrology», vol. 67 (3), 1978, pp. 227-232; S. Tumiati, *Geochemistry, mineralogy and petrology of the eclogitized manganese deposit of Praborna (Valle d'Aosta, Western Italian Alps)*, cit.

[53] L. Colomba, *Sopra un granato ferri-cromifero di Praborna (S. Marcel)*, cit.

6.2.8 Feldspars

At Praborna, feldspars occur as retrograde minerals that formed after high-pressure minerals, in the form of symplectites. Nearly pure albite occurs as symplectites after omphacitic pyroxene, alongside jadeite-poor pyroxene (Fig. 5.7a, b) and after piemontite, together with hematite and diopside-rich clinopyroxene. More-or-less Ba-rich K-feldspar (i.e., hyalophane) also occurs as symplectites after piemontite, together with hollandite and Sr-rich calcite (Fig. 5.7c, d) and after alurgite, alongside Mn-rich phlogopite (Fig. 5.7e, f). Hyalophane has a maximum Ba-content of 41.2 mol% of the celsian end-member ($BaAl_2Si_2O_8$). Its presence implies Ba mobility during retrograde metamorphism.

Additionally, albite and K-feldspar, alongside quartz, carbonates, titanite, tremolite and trace amounts of barite, form light-coloured post-peak matrices. These minerals also occur in late veins that intersect and infiltrate early parageneses.

6.2.9 Titanite and «Greenovite»

At Praborna, titanite ($CaTiSiO_5$) typically occurs in Ca-rich rocks as a retrograde product after rutile, forming coronas around it. Furthermore, euhedral, pink titanite – once called «greenovite» – is a quite common accessory mineral of veins and post-peak parageneses (Fig. 6.12b).

In 1840, Armand Dufrénoy studied pink crystals that had been collected in Praborna by Jean-Pierre Bertrand de Lom[54]. He described it as a new species and named it greenovite after the English geologist George Greenough[55]. However, three years later, August Breithaupt suggested that greenovite was actually a variety of titanite[56]. This was confirmed through chemical analysis first by Achille Delesse in 1844 and then by Charles de Marignac in 1845, who

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[54] 7/6/1840, *Description minéralogique et géognostique du dépot de minerai de manganèse du haut de la combe de St. Marcel, vallée d'Aosta, Piémont [par Bertrand de Lom],* FD 11 J 423; 15/9/1840, *Lettre de Bertrand-de-Lom à Despine...*, FD 11 J 423; J.P. Bertrand de Lom, *Considérations minéralogiques concernant l'origine d'un oxide de titane condensé*, in «Echo du Monde savant», 11ème année (n° 7, 28 janvier 1844), col. 152-153.

[55] A. Dufrénoy, *Description de la Greenovite*, in «Annales des Mines», (3ème sér.) vol. 17, 1840, pp. 529-545 + pl. X; A. Dufrénoy, *Description de la Greenovite*, in «Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences», vol. 11, 1840, p. 234.

[56] A. Breithaupt, *Ueber den greenovit*, in «Annalen der Physik und Chemie», vol. 134 [ser. 2, vol. 58], 1843, pp. 277-278.

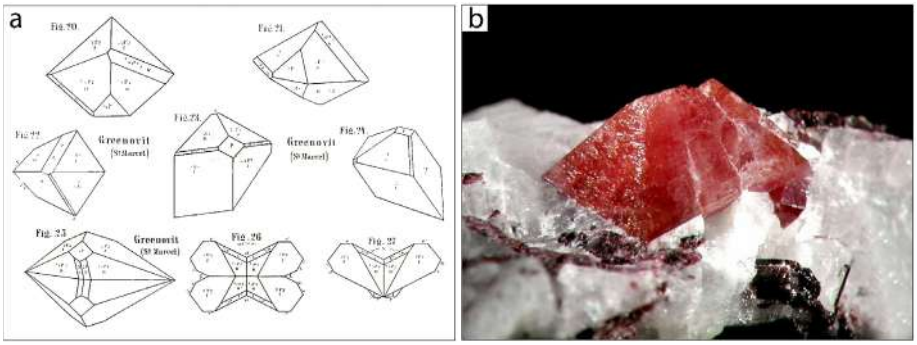

Figure 6.12. «Greenovite» variety of titanite.

(a) «Greenovite» crystal shapes after F. Hessenberg, Greenovit von St. Marcel, in «Abhandlungen, herausgegeben von des Senckenbergischen Naturforschenden Gesellschaft», Bd. 7, 1869-1870, pp. 17-27 + Taf. 2-3; Figures 25-27 show the twinning typical of greenovite.

(b) «Greenovite» (i.e., pink titanite).

© (b) Raffaele Prete.

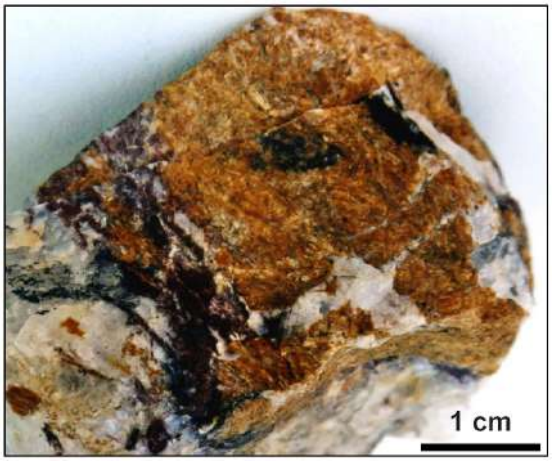

Figure 6.13. Ardennite.

Macrophotograph of ardennite (brown) in association with piemontite (dark purple) and quartz (white), taken from sample C9 which was collected by Paolo Mietto and studied by Micaglio in 2004.

both concluded that it was an Mn-bearing variety of titanite[57]. This was also corroborated by the mineralogical studies of Alfred Des Cloizeaux and Friedrich Hessenberg (Fig. 6.12a)[58]. More recently, Mottana and Griffin (1979) demonstrated that Mn^{2+}substituted some of the Ca^{2+} in titanite to form greenovite[59]. They proposed that the pink colour of greenovite is due to a relatively high Mn/Fe ratio, whereas Tumiati (2005) suggested the involvement of other chromophore trace ions, such as Sb^{5+}, As^{5+} or V^{5+}. Regardless of the origin of its colour, greenovite should now be considered a variety *ex-colore* of titanite.

In basal levels 1-2 of the lithological sequence, titanite commonly occurs in late-stage cm-sized veinlets. In Cr-rich Level 3, it forms coronas around rutile, as well as large, euhedral crystals associated with Cr-epidote, Cr-mica and gold. In these levels, titanite crystals are commonly zoned. Their core is close to the standard $CaTiSiO_5$ composition and evolves into peculiar Sb-rich compositions towards the rims, where Ti^{4+} and Ca^{2+} are partially substituted by (Sb^{5+}, Cr^{3+}, Fe^{3+}, Al^{3+}) and (Sr^{2+}, Ba^{2+}, $Mn^{2+,}$ Fe^{2+}), respectively[60]. Titanite is also widespread in the other levels, including the country rocks, but it does not contain Sb nor display the pink colour of greenovite.

6.2.10 Other silicates

Tephroite (Mn_2SiO_4) is the manganese end-member of the olivine group. At Praborna, it has been reported in two SiO_2-depleted quartz-free samples collected in the dump of the mine, and studied respectively by Micaglio,

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[57] A. Delesse, *Analyse de la Greenovite*, in «Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences», vol. XIX, 1844, pp. 1019-1020; A. Delesse, *Analyse de la Gréenovite*, in «Annales des Mines», (4ème sér.) vol. 6, 1844, pp. 325-336; C. de Marignac, *Notices minéralogiques: Greenovite*, in «Annales de Chimie et de Physique», (3ème sér.) vol. 14, 1845, pp. 47-49.

[58] A. Des Cloizeaux, *Mémoire sur les formes cristallines de la greenovite; et réunion de cette substance au sphène*, in «Annales de Chimie et de Physique», (3ème sér.) vol. 20, 1847, pp. 84-91 + pl. I.; F. Hessenberg, *Greenovit von St. Marcel*, in «Abhandlungen, herausgegeben von des Senckenbergischen Naturforschenden Gesellschaft [Frankfurt]», Bd. 7, 1869-1870, pp. 17-27 + Taf. 2-3.

[59] A. Mottana, W.L. Griffin, *Pink titanite (greenovite) from St. Marcel, Valle d'Aosta, Italy*, in «Rendiconti della Società Italiana di Mineralogia e Petrologia», vol. 35 (1), 1979, pp. 135-143.

[60] E.-A. Perseil, D.C. Smith, *Sb-rich titanite in the manganese concentrations at St. Marcel-Praborna, Aosta Valley, Italy: petrography and crystal chemistry*, in «Mineralogical Magazine», vol. 59, 1995, pp. 717-734; S. Tumiati, *Geochemistry, mineralogy and petrology of the eclogitized manganese deposit of Praborna (Valle d'Aosta, Western Italian Alps)*, cit.

Tumiati, and Tumiati *et al.*[61], and by Cenki-Tok and Chopin, and Cenki-Tok *et al.*[62] (see Section 5.2.8).

Tiragalloite ($Mn^{2+}_4\ As^{5+}Si_3O_{12}(OH)$) has been observed as rare μm-sized grains[63].

Ardennite, a rare Mn-rich silicate containing vanadium and arsenic, is another curiosity of the Praborna mine. First observed in the nearby deposit of Varenche (Saint-Barthélemy, Nus)[64], ardennite has only recently been reported and studied at Praborna (Fig. 6.13)[65].

6.3 Other minerals

6.3.1 Carbonates

Carbonates are common at Praborna. Mn-bearing calcite, in some cases in equilibrium with minor Ca-bearing rhodochrosite ($MnCO_3$), mostly occurs in veins, particularly in the upper levels of the sequence. Calcite also occurs in symplectites after piemontite (Fig. 5.7d), where it typically recycles the strontium originally present in the piemontite, which results in an Sr/(Sr + Ca) ratio of up to 0.077. Calcite may contain μm-sized exsolutions of strontianite ($SrCO_3$), barite and, less frequently, witherite ($BaCO_3$). Kutnahorite ($CaMn(CO_3)_2$), the analogue of dolomite in the calcite–rhodochrosite system, has also been reported.

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[61] C. Micaglio, *Le ardenniti di St. Marcel e di Chambave (Valle d'Aosta)*, cit.; S. Tumiati, *Geochemistry, mineralogy and petrology of the eclogitized manganese deposit of Praborna (Valle d'Aosta, Western Italian Alps)*, cit.; S. Tumiati *et al.*, *Ultra-oxidized rocks in subduction mélanges? Decoupling between oxygen fugacity and oxygen availability in a Mn-rich metasomatic environment*, cit.

[62] B. Cenki-Tok, C. Chopin, *Coexisting calderite and spessartine garnets in eclogite-facies metacherts of the Western Alps*, cit.; B. Cenki-Tok, A. Ragu, T. Armbruster, C. Chopin, O. Medenbach, *New Mn- and rare-earth-rich epidote-group minerals in metacherts: manganiandrosite-(Ce) and vanadoandrosite-(Ce)*, cit.

[63] B. Cenki-Tok, C. Chopin, *Coexisting calderite and spessartine garnets in eclogite-facies metacherts of the Western Alps*, cit.

[64] A. Pelloux, *Contributo alla mineralogia della Valle d'Aosta*, in «Rendiconti della Società Mineralogica Italiana», vol. 3, 1946, pp. 188-206; A.A. Barresi, P. Orlandi, M. Pasero, *History of ardennite and the new mineral Ardennite-(V)*, in «European Journal of Mineralogy», vol. 19 (4), 2007, pp. 581-587.

[65] C. Micaglio, *Le ardenniti di St. Marcel e di Chambave (Valle d'Aosta)*, cit.; S. Tumiati, *Geochemistry, mineralogy and petrology of the eclogitized manganese deposit of Praborna (Valle d'Aosta, Western Italian Alps)*, cit.

Brown *et al.* (1978) reported the occurrence at Praborna of a nucleus of Ba-rich aragonite in a calcite crystal, and Barresi (2001) also observed aragonite at Varenche. Since aragonite is the high-pressure polymorph of calcite, its presence likely reflects the high-pressure stage of metamorphism.

6.3.2 Phosphates, vanadates, sulfates

Fluorapatite ($Ca_5(PO_4)_3F$) from Praborna may contain significant amounts of As and Sr, which replace P and Ca, respectively (Fig. 6.14)[66].

A Ca- and REE-bearing orthovanadate, identified as Ca- and Y-bearing wakefieldite-(Ce), has been found in Level 3 as μm-sized euhedral crystals in clinopyroxene + plagioclase symplectites replacing eclogite-facies vanadium-bearing omphacite[67]. This mineral, a rare and scarce by-product of omphacite breakdown, was formed under ultra-oxidised conditions, during the retrogression to greenschist facies.

Barite occurs as late veinlets. Another sulfate, posnjakite, has been recently found at Praborna[68].

6.3.3 Sulphides

One of the most unusual features of Praborna is the almost complete absence of sulphides. In most ore deposits, sulphides such as pyrite, chalcopyrite or galena are abundant. At Praborna, however, the highly oxidising conditions prevented their formation. Instead, chalcophile elements – in particular Sb and As – were incorporated into oxides and silicates, contributing to their peculiar compositions. However, a Fe–Co sulphide has been mentioned in one sample of level 6, in the less oxidised area of the ore.

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[66] E.-A. Perseil, P. Blanc, D. Ohnenstetter, *As-bearing fluorapatite in manganiferous deposits from St. Marcel-Praborna, Val d'Aosta, Italy*, in «The Canadian Mineralogist», vol. 38, 2000, pp. 101-117.

[67] S. Tumiati, M. Merlini, G. Godard, M. Hanfland, P. Fumagalli, *Orthovanadate wakefieldite-(Ce) in symplectites replacing vanadium-bearing omphacite in the ultra-oxidized manganese deposit of Praborna (Aosta Valley, Western Italian Alps)*, in «American Mineralogist», vol. 105, 2020, pp. 1242-1253.

[68] F. Vanini, M.E. Ciriotti, E. Bittarello, F.L. Bonino, P. Brizio, *Posnjakite, primo ritrovamento di un minerale di rame alla miniera di Prabornaz, Saint-Marcel, Valle d'Aosta*, in «Micro», vol. 22, 2024, pp. 370-374.

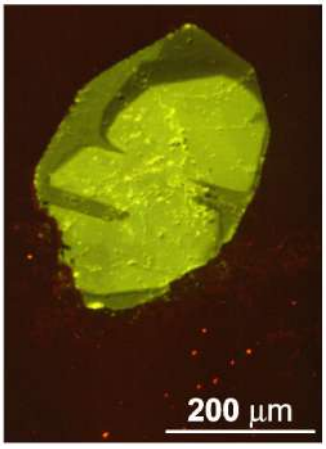

Figure 6.14. Fluorapatite from Praborna as observed using cathodoluminescence.

Cathodoluminescence reveals several crystal overgrowths, due to the partial replacement of P by As, resulting in lower cathodoluminescence intensity (Perseil *et al.*, 2000).

Figure 6.15. Gold.

Native gold in a green clinopyroxene-rich matrix.

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6.3.4 Gold

Barelli (1845), Millosevich (1906, 1907) and Colomba (1910) were the first to describe native gold at Praborna[69], which they presumably found in Cr-rich Level 3. We also observed gold crystals measuring 20-80 μm in size in this level. They occur alongside pyroxene, calcite, microcline, quartz, winchite-tremolite amphibole, Cr-bearing mica, epidote and As-bearing titanite. These features suggest that the gold has a «listvenitic» origin, being mesothermal gold formed through the hydrothermal alteration of serpentinites by a fluid with high CO_2 activity.

[69] V. Barelli, *Cenni di statistica mineralogica degli stati di S. M. il Re di Sardegna…*, cit.; F. Millosevich, *Sopra alcuni minerali di Val d'Aosta*, in «Atti della R. Accademia dei Lincei. Rendiconti. Classe di Scienze fisiche, matematiche e naturali», ser. 5, vol. XV (1° sem.), 1906, pp. 317-321.; F. Millosevich, *Sopra alcuni minerali di Val d'Aosta*, in «Rivista di Mineralogia e Cristallografia Italiana», vol. 33, 1907, pp. 34-40; L. Colomba, *Sopra un granato ferri-cromifero di Praborna (S. Marcel)*, cit.

CONCLUSION

Since its first recorded mention in 1402, the Praborna mine has supplied the manganese that renders glass colourless and transparent, enabling Venetian glassmakers to produce the precious *cristallo*. For nearly four centuries, this manganese ore was used to make glassware for princes' tables, mirrors for castles, reliquaries for churches and even lenses for Galileo's telescope. Despite the efforts of the Most Serene Republic of Venice to preserve the secret of its manufacture, the technique eventually spread throughout Europe. In France, the *Manufacture royale des glaces* – now known as the Saint-Gobain Company – disclosed the technique through an espionage operation organised by Minister Colbert that reads like something from an Alexandre Dumas novel. Today, Praborna manganese can be found in countless works of art and mirrors scattered throughout museums and monuments across Europe, including the *Museo del Vetro* in Murano, the *Glasmuseum* in Wertheim and the *Galerie des glaces* at the Palace of Versailles. However, the black manganese oxide from Praborna has become invisible to visitors, as its function was precisely to render the «crystal» transparent.

The Praborna deposit is also unique from a scientific perspective. The exceptional diversity of its minerals, from the violet-blue violan to the deep-red piemontite, from massive braunite bodies to delicate veins of pyroxmangite, as well as the scientific importance of its rocks, has made it the subject of over 300 mineralogical and petrological studies since the 18th century. Three factors have combined to make this deposit exceptional: First, the hydrothermal activity that occurred on the seabed of the ancient Piedmont Ocean during the Jurassic period produced peculiar Mn-rich formations. Subsequently, high-pressure eclogite-facies metamorphic conditions, linked to the subduction of this ancient oceanic lithosphere, resulted in the formation of uncommon rocks and minerals. Finally, the high degree of manganese oxidation prevented the formation of sulphides, forcing chalcophile elements (such as Sb, As, Cu, etc.) to become incorporated into silicates or oxides, which resulted in their unusual compositions. Praborna has thus become the type locality for about ten mineral species or varieties. It is now an open-air museum of mineralogy that delights lovers of beautiful crystals and crystallographers alike.

https://doi.org/10.14672/QUAD2026-47-7

Despite its state of near-total disrepair and the occasional bout of looting, the ancient Praborna mine is a remarkable site and an important part of our historical and mineralogical heritage. Hopefully, future generations of historians and mineralogists will be committed to promoting and, above all, preserving it.

NOTES
&
BIBLIOGRAPHY

NOTES

Abbreviations

The following abbreviations are used to introduce references to archives:

FC *m-n*: Fonds Challant, volume *m*, article *n*; *Archivio storico regionale, Regione Autonoma Valle d'Aosta, Aoste/Aosta, Italia*.

FD 11 J *n*: Fonds Despine, cote 11 J *n*, *Archives départementales de Haute-Savoie, Annecy, France*.

AST SC: *Archivio di Stato di Torino, Sezione Corte, Torino, Italia.*

AST SR: *Archivio di Stato di Torino, Sezioni Riunite, Torino, Italia*.

ASV: *Archivio di Stato di Venezia, Venezia, Italia.*

ANF: *Archives nationales de France, Pierrefitte-sur-Seine, France*.

ASG FH: *Archives de Saint-Gobain, Fonds Historique, Blois, France*.

Units and currencies

Before the adoption of the metric system in 1845, quantities of material were expressed using the following units of mass (in French/*in Italian*):

Rup(s)/*Rubbo(i)*: 1 rup of Aosta = 9.615 kg, according to the official conversion rate in the Aosta Valley at the beginning of the 19th century[1]. Although this conversion rate appears accurate, it may have changed over time.

Millier(s)/*Migliara* or *Milliara*[2]: One *migliara* of Aosta = 1000 pounds =

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[1] A. Martini, *Manuale di metrologia...*, E. Loescher, Torino 1883, pp. 19, 38-39.

[2] See FC 161-1B; FC 165-6; FC 165-7.

40 rups = ca. 385 kg = ca. 0.385 metric tonne. One *migliara* of Venice = ca. 65 rups of Aosta = ca. 625 kg.

Other units are unevenly used in the archives: *libbra grossa di Venezia* = 12 *once* = 0.477 kg; 1 *ballino* = 5 rups.

Before the French Revolution, the currency in use in the Aosta Valley was the Piedmontese *Lira*. Prices were expressed (in French/*in Italian*) in the format ***l:s:d***, where ***l*** was the number of livre(s)/*lira(e)*; one livre/*lira* was subdivided into 20 sols or sous/*soldi* (***s***), each of which was subdivided into 12 deniers/*denari* (***d***). The following currencies were also used: écu(s)/*scudo(i)* (1 écu/*scudo piedmontese* = 6 livres/*lire*); florin(s)/*fiorino(i)*; and Venetian ducat(s)/*ducato(i)*. During the Napoleonic period, the currency used in the *département de la Doire* was the Franc Germinal (1 Fr = 4.5 g of fine silver). After the restoration of the House of Savoy, the decimal *Lira sabauda* was introduced, maintaining the same parity with the Franc until the First World War.

Languages and vocabulary

Following the Edict of Rivoli in 1561, French became the official language of the Duchies of Aosta and Savoy, while Italian became the official language of Piedmont and the County of Nice. Previously written in Latin, official texts in the Aosta Valley were then written in French. However, letters and contracts drawn up with people from outside the Aosta Valley and Savoy were written in Italian. Depending on the context, the same name might appear in French (e.g., Joseph-Félix; Saint-Marcel), or in Italian (Giuseppe Felice; San Marcello). For simplicity, we have used French names for places and people from the Aosta Valley and Savoy – particularly members of the Challant family and the Dukes of Savoy – and Italian for all others.

The material extracted from the Praborna mine and transported to Venice or elsewhere was referred to as «manganese», «maganese», «manganel», etc. However, this was not manganese in the modern sense (i.e., the chemical element Mn), but rather a mixture of manganese oxides, mainly braunite, and various other minerals. For the sake of convenience, we have retained the term «manganese» when citing ancient texts.

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The research that underpins the petrological and mineralogical results presented in this volume was carried out with the support of the University of Insubria (Como, Italy) and the Université Denis-Diderot (Paris, France) between 2001 and 2007, and subsequently with the support of the Universities of Milan (Simone Tumiati) and Paris-Cité (Gaston Godard) from 2008 to 2022. Archive research was made possible thanks to financial contributions from Gaston Godard and Silvana Martin. The publication of this volume also benefited from financial contributions from Padova University's Department of Geosciences and Silvana Martin.

Glossary of mineral names

The Praborna and Varenche deposits contain unusual minerals, which are referenced in the text or in the cited bibliography. For the reader's convenience, a list of these minerals is provided in alphabetical order below, along with their chemical formulas, groups or supergroups, and common abbreviations. □ means empty site.

actinolite $Ca_2(Mg_{4.5\text{-}2.5}Fe_{0.5\text{-}2.5})Si_8O_{22}(OH)_2$ clinoamphibole

aegirine $NaFe^{3+}Si_2O_6$ clinopyroxene (Aeg)

albite $Na(AlSi_3O_8)$ feldspar (Ab)

almandine $Fe^{2+}_3Al_2(SiO_4)_3$ garnet (Alm)

alurgite – a pink, Mn-bearing phengitic mica

andradite $Ca_3Fe^{3+}_2(SiO_4)_3$ garnet

androsite $(Mn^{2+}REE)(Al_2Mn^{2+})O[Si_2O_7][SiO_4]$ (OH) epidote

annite $KFe^{2+}_3(AlSi_3O_{10})(OH)_2$ trioctahedral mica

anorthite $Ca(Al_2Si_2O_8)$ feldspar (An)

apatite $Ca_5(PO_4)_3(OH, F)$

aragonite $CaCO_3$ carbonate

ardennite-(As) $Mn^{2+}_4Al_4(AlMg)(AsO_4)(SiO_4)_2(Si_3O_{10})(OH)_6$

ardennite-(V) $Mn^{2+}_4Al_4(AlMg)(VO_4)(SiO_4)_2(Si_3O_{10})(OH)_6$

arseniopleite $NaCaMnMn_2(AsO_4)_3$

augite $(Ca,Na)(Mg,Fe^{2+},Fe^{3+},Al)Si_2O_6$ clinopyroxene

azurite $Cu_3(CO_3)_2(OH)_2$

barite $BaSO_4$

birnessite $(Na,Ca)_{0.5}(Mn^{4+},Mn^{3+})_2O_4 \cdot 1.5H_2O$

bixbyite (partridgeite) $Mn^{3+}_2O_3$

braunite $Mn^{2+}Mn^{3+}_6(SiO_4)O_8$

brochantite $Cu_4(SO_4)(OH)_6$

bustamite $CaMn^{2+}(Si_2O_6)$

calcite $CaCO_3$ (Cal)

calderite $Mn^{2+}_3Fe^{3+}_2(SiO_4)_3$ garnet (Cald)

cavoite $CaV^{4+}_3O_7$

celadonite $K(MgFe^{3+}\square)(Si_4O_{10})(OH)_2$ dioctahedral mica

celestine $SrSO_4$

celsiane $Ba(Al_2Si_2O_8)$ feldspar (Cls)

chamosite $Fe^{2+}_5Al(AlSi_3O)_{10}(OH)_8$ chlorite

chloritoid $Fe^{2+}Al_2O(SiO_4)(OH)_2$

chrome-diopside – a Cr-bearing diopside

chromphyllite $KCr_2(AlSi_3O_{10})(OH)_2$ dioctahedral mica

clinochlore $Mg_5Al(AlSi_3O_{10})(OH)_8$ chlorite

clinozoisite $Ca_2Al_3O[Si_2O_7][SiO_4](OH)$ epidote (Czo)

coesite SiO_2

cryptomelane $K(Mn^{4+}_7Mn^{3+})O_{16}$ cryptomelane series

cummingtonite $\square Mg_2Mg_5(Si_8O_{22})(OH)_2$ clinoamphibole

danburite $CaB_2Si_2O_8$

dannemorite – see manganogrunerite

diopside $CaMgSi_2O_6$ clinopyroxene (Di)

djurleite $Cu_{31}S_{16}$

eastonite $KMg_2Al(Al_2Si_2O_{10})(OH)_2$ trioctahedral mica

epidote $Ca_2(Al_2Fe^{3+})O[Si_2O_7][SiO_4](OH)$ epidote

ferroceladonite $K(Fe^{2+}Fe^{3+}\square)(Si_4O_{10})(OH)_2$ dioctahedral mica

fluorapatite $Ca_5(PO_4)_3F$

fluorcalcioroméite $(Ca,Na,\square)_2Sb^{5+}{}_2(O,OH)_6F$ roméite series

fuchsite – a Cr-bearing muscovite

galaxite $Mn^{2+}Al_2O_4$ spinel

glaucophane $\square Na_2(Mg_2Al_2)Si_8O_{22}(OH)_2$ clinoamphibole

goethite $Fe^{3+}O(OH)$

gold Au

greenovite – a pink-coloured variety of titanite

grossular (grossularite) $Ca_3Al_2(SiO_4)_3$ garnet (Grs)

grunerite $Fe^{2+}{}_7Si_8O_{22}(OH)_2$ clinoamphibole

hausmannite $Mn^{2+}Mn^{3+}{}_2O_4$ spinel

hedenbergite $CaFe^{2+}Si_2O_6$ clinopyroxene (Hd)

hematite Fe_2O_3

henritermierite $Ca_3Mn^{3+}{}_2(SiO_4)_2[\square(OH)_4]$ garnet

hollandite $Ba(Mn^{4+}{}_6Mn^{3+}{}_2)O_{16}$ cryptomelane series

hyalophane – solid solution of microcline and celsiane

ilmenite $Fe^{2+}TiO_3$

jacobsite $Mn^{2+}Fe^{3+}{}_2O_4$ spinel

jadeite $NaAlSi_2O_6$ clinopyroxene (Jd)

johannsenite $CaMn^{2+}Si_2O_6$ clinopyroxene

kämmererite – Cr-bearing clinochlore

kanonaite $Mn^{3+}Al(SiO_4)O$

kosmochlor $NaCr^{3+}Si_2O_6$ clinopyroxene

kutnohorite $CaMn^{2+}(CO_3)_2$ carbonate

manganiandrosite-(Ce) $(Mn^{2+}Ce)(Mn^{3+}AlMn^{2+})O[Si_2O_7][SiO_4](OH)$ epidote

manganiceladonite $K(MgMn^{3+}\square)(Si_4O_{10})(OH)_2$ dioctahedral mica

manganite $Mn^{3+}O(OH)$

mangano-clinozoisite $(Ca,Mn)_2Al_3O[Si_2O_7][SiO_4](OH)$ epidote

manganocummingtonite (tirodite) $\square(Mn^{2+}{}_2)(Mg_5)(Si_8O_{22})(OH)_2$ clino-amphibole

manganogrunerite (dannemorite) $\square(Mn^{2+}{}_2)\{Fe^{2+}{}_5\}(Si_8O_{22})(OH)_2$ clino-amphibole

manganophyllite – see shirozulite

manganosite MnO

mariposite – a Cr-bearing phengite

marceline – ancient name of braunite

microcline $KAlSi_3O_8$ feldspar

muscovite $KAl_2(AlSi_3)O_{10}(OH)_2$ dioctahedral mica (Ms)

namansilite $NaMn^{3+}Si_2O_6$ clinopyroxene (Nam)

neotocite $(Mn,Fe)SiO_3 \cdot H_2O$

omphacite $(Ca,Na)(Mg,Al)Si_2O_6$ clinopyroxene (Omp)

partridgeite – see bixbyite

parvowinchite $Na(Mn^{2+}Na)(Mg_4Fe^{3+})Si_8O_{22}(OH)_2$ clinoamphibole

pennantite $Mn^{2+}{}_5Al(AlSi_3O_{10})(OH)_8$ chlorite

phengite – a celadonitic dioctahedral mica (Ph)

phlogopite $KMg_3(AlSi_3)O_{10}(OH)_2$ trioctahedral mica (Phl)

piemontite $Ca_2Al_2Mn^{3+}O[Si_2O_7][SiO_4](OH)$ epidote (Pmt)

posnjakite $Cu_4(SO_4)(OH)_6 \cdot H_2O$

priderite $K(Ti^{4+}{}_7Fe^{3+})O_{16}$

pyrochroite $Mn(OH)_2$

pyrolusite $Mn^{4+}O_2$

pyrope $Mg_3Al_2(SiO_4)_3$ garnet (Prp)

pyrophanite $MnTiO_3$ (Pph)

pyroxmangite $MnSiO_3$ (Pxm)

quartz SiO_2 (Qz)

rhodochrosite $MnCO_3$ carbonate (Rds)

rhodonite $CaMn_3Mn[Si_5O_{15}]$

richterite $Na(NaCa)Mg_5(Si_8O_{22})(OH)_2$ clinoamphibole

roméite (roméine) – A series between Oxyplumboroméite and Fluorcalcioroméite

rutile TiO_2

schefferite – A brown Mn-bearing variety of diopside

shirozulite (manganophyllite) $KMn^{2+}_3(Si_3Al)O_{10}(OH)_2$ trioctahedral mica

siderophyllite $KFe^{2+}_2Al(Al_2Si_2O_{10})(OH)_2$ trioctahedral mica

sismondine – ancient name of chloritoid

spessartine $Mn^{2+}_3Al_2(SiO_4)_3$ garnet (Sps)

sphene – see titanite

strontianite $SrCO_3$ carbonate

strontiomelane $SrMn^{3+}_2Mn^{4+}_6O_{16}$ cryptomelane series

strontiopiemontite $CaSrAl_2Mn^{3+}O[Si_2O_7][SiO_4](OH)$ epidote

sudoite $Mg_2Al_3(AlSi_3)O_{10}(OH)_8$ chlorite

sursassite $Mn^{2+}_2Al_3(SiO_4)(Si_2O_7)(OH)_3$

tawmawite – a Cr-bearing epidote

tephroite Mn_2SiO_4 olivine (Tep)

tirodite – see manganocummingtonite

tiragalloite $Mn^{2+}_4\ As^{5+}Si_3O_{12}(OH)$

titanite (sphene) $CaTiSiO_5$ (Ttn)

tremolite □$Ca_2Mg_5(Si_8O_{22})(OH)_2$ clinoamphibole

uvarovite $Ca_3Cr_2(SiO_4)_3$ garnet

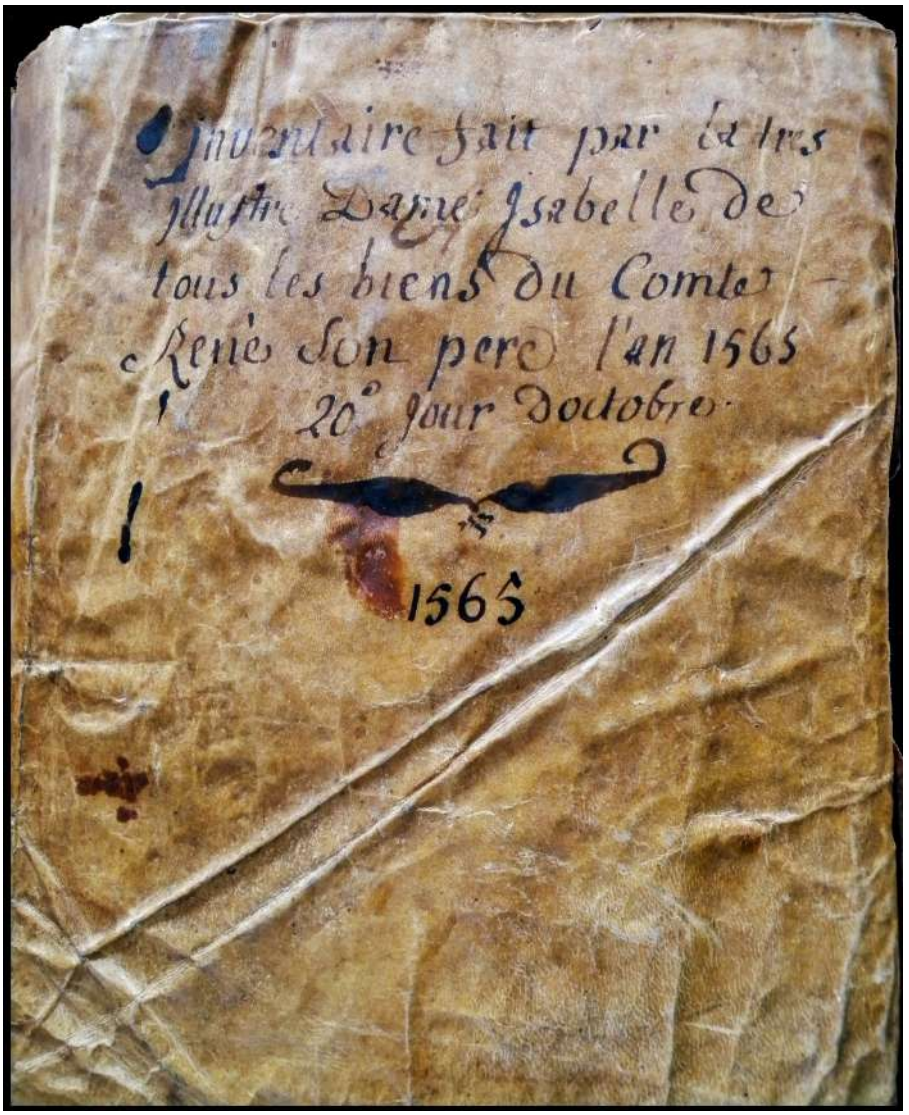
violan (violane) – a violet variety of omphacite or diopside

wakefieldite-(Ce) $(Ce,Ca,Y)(V,Cr)O_4$ vanadate

winchite □$(NaCa)Mg_4AlSi_8O_{22}(OH)_2$ clinoamphibole

witherite $BaCO_3$

zircon $ZrSiO_4$



Vellum cover of volume 55 of the Challant collection (FC-55): «*Inventaire fait par la tres illustre Dame Isabelle de tous les biens du Comte René son pere l'an 1565 20e jour doctobre — 1565*». This volume contains copies of the earliest references to the Praborna mine, dating from 1402 and 1411.

The signature and seal of Charles-Emmanuel II, Duke of Savoy, Prince of Piedmont and King of Cyprus, affixed to a document dated 18 September 1670 and relating to the 1670 lawsuit about the ownership of the Praborna mine, opposing Carlo Filippo Perrone and François-Jérôme de Challant (FC 162-3).

ARCHIVES

The archival documents relating to the Praborna and Varenche mines are listed here in chronological order. Please refer to the «Notes» section for an explanation of the abbreviations used. Depending on the language of the document, titles (written in italics) are given in the original language (Italian or French) or translated into English if the text is in Latin.

24/5/1323, *Testament of Ebal de Challant*, FC 10-5 [4 doc. including 1 parchment; in Latin].

23/8/1402 (1565 copy), *Instrument de vendition faicte dicelle montaigne par ven[erable] george guisiaco Cure de Sainct marcel a fieud a marcel palliet filz d'aimonet paliet*, FC 55, f. 256v.

18/11/1411 (1565 copy), *Instrument de v[endici]on faicte au Seignieur Jaques de Challant par Aimonet et Vincent filz de marcel paliet et maurizet leur vncle d'une montaigne situee en la val de riuier appelle pra borna*, FC 55, ff. 256r-256v.

10/5/1415, *Copia della transazione del 10 maggio 1415, con la quale si dichiarano i beni di S. Marcello con il manganese, stipulata tra il signor Francesco de Challant da una parte e la signora Amedea de Ferreriis di Pinerolo dall'altra*, FC 162-3.

10/5/1415, *Donation with enfeoffment made by Lord Francesco di Challant in favour of Lords Francesco, Nicolas, Claudio and Antonio, brothers and sons of the late Lord Pietro di Challant, [... of] the castles and places of Ussel, San Marcello, mine called Manganese*, FC 162-5.

1477-1486, *Reports by Jacquemin de Tillier, Castellan of Ussel and St-Marcel, regarding the incomes and expenses on behalf of Lord Louis de Challant*, FC 172-02 [6 booklets in Latin: 1477-1479, 1480-1483, 1482-1483, 1484-1485, 1485-1486].

1488-1489, *Account rendered by Giacomino de Tillier, Castellan of the districts of Ussel and St-Marcel, to Mr Giorgio di Challant, Apostolic Prothonotary, and to Lady Margarita de La Chambre, Countess of Challant*, FC 172-3 [1 booklet in Latin].

1505-1506, *Account rendered by Pietro di Villario, Castellan of Ussel and*

St-Marcel, to Lord Giacomo di Challant, Lord of Aymavilles, detailing the annual income and taxes of the aforementioned fiefs of Ussel and St-Marcel, FC 172-8.

19/7/1508 (1565 copy), *Instrument de paches faictes par magniffique seignieur Jaques de Challant et noble Anthoine de Salatico a cause de manganel de Sainct Marcel*, FC 55, ff. 145r-145v.

14/12/1550, *Le comte René de Challant donne à sa femme Mencie du Portugal la faculté de prendre 32 milliers de manganèse des minières de St-Marcel*, FC 166-1 [écriture gothique].

8/10/1573, *Isabelle de Challant vend 100 milliers de manganèse de St-Marcel*, FC 261-10.

15/6/1591, *Atti di spartizione compiuti tra François de Challant, barone di Fénis, e Georges de Challant, barone di Châtillon*, FC 162-3.

10/9/1596, *Adrienne Costa, veuve du seigneur Georges de Challant, en qualité de tutrice de ses fils, donne à bail pour cinq ans à noble Charles Perrone les mines de manganèse de St-Marcel pour y extraire chaque année 30 milliers de minéral pour le prix de 400 écus*, FC 161-1A [écriture gothique].

13/4/1600, *Adriana Costa affitta le miniere di manganese di St-Marcel a Carlo Perrone per 800 scudi*, FC 161-2B.

24/10/1604, *Dazione in paga al signor conte Carlo Perrone, creditore dei signori Castiglione di Chialant di scudi 800, delle miniere di Revers, di San Marcello e della segretaria di Castiglione*, AST SR, Perrone di San Martino, partizione 1, cartella 4, fascicolo 58.

24/10/1604, *Dazione in paga fatta dalla dama Adriana di Challant come madre e tutrice dei signor Paolo Emanuele di Challant, col patto di riscatto perpetuo, a favore del signor auditore Carlo Perrone S. Martino, della miniera e cava del manganese della montagna di Revers di S. Marcello...*, FC 161-2A, FC 165-3.

7/3/1609, *Paolo Emanuele di Challant approva tutti i contratti stipulati da sua madre*, FC 161-3.

28/2/1611, *Lettera di Francesco Battiano al barone de Châtillon riguardante l'estrazione del manganese e la controversia con Carlo Perrone*, FC 165-4.

10/12/1611, *Paolo Emanuele di Challant, barone di Châtillon, promette di fornire ad Agostino Gromo, di Biella, e a Giovanni e Giuseppe Desio, di Milano, la quantità di 80 migliara (di 40 rubbi d'Aosta ciascuno) di manganese di St. Marcel, durante 7 anni, al prezzo di un fiorino per rubbo*, FC 161-1B.

1612, *Atto della causa intentata dal barone Paolo Emanuele di Challant contro il conte Perrone di San Martino, riguardante l'annullamento del contratto di vendita delle miniere di manganese di St-Marcel, fatto da Adriana Costa di Challant*, FC 165-28 [9 pages printed in Latin and Italian].

1612, *Calcul du profit que peut apporter la vente de cent milliers de manganèse de St-Marcel, transporté à Venise*, FC 165-7.

1612, *Patto di perpetua riscatto insieme alla segreteria ed emolumenti d'essa del luogo di Castiglione, per pagamento della somma di scudi 1800 e fiorini 7 in virtù dell'instromento delli 24 ottobre 1604 quivi tenorisato*, FC 161-3.

1612, *Registro del manganese registrato dai portatori, a Châtillon, a nome di Augustin Gromo*, FC 165-9.

1612, *Copia di cedola del signor barone di Castiglione relativa alla vendita della miniera [di Praborna] a favore di Carlo Perrone*, AST SR, Perrone di San Martino, partizione 1, cartella 4, fascicolo 57.

2/4/1612, *Memoria di Giovanni Francesco Battiano sulle miniere di manganese di St-Marcel e atto del processo tra il barone di Châtillon e Carlo Perrone*, FC 161-5.

30/4/1612, *Giovanni Marineto, master glassmaker of Murano, states that Murano glassmakers can use 40 migliara of manganese each year*, FC 165-5 [in Latin and Italian; lead seal of the Doge Leonardo Donato].

16/5/1612, *Le juge de la baronnie de Châtillon ordonne au notaire Jean-Pierre Chandieu de faire une copie de l'acte de bail des mines de manganèse de St-Marcel, fait par Adrienne Costa de Challant au recourant en 1600 ou 1601*, FC 293-31 [écriture gothique].

1612, *Atto del processo tra il barone di Châtillon e Perrone di San Martino a proposito della miniera di manganese di St-Marcel*, FC 165-30.

17/6/1612, *Agostino Gromo, di Biella, e Giovanni e Giuseppe Desy, di Milano, fanno appello al Duca di Savoia riguardo all'acquisto di cento migliara (di 40 rubbi ciascuno) di manganese all'anno, per nove anni, fatto con il Barone di Châtillon, con atto del 17 giugno 1612*, FC 165-6 [Il Duca ordina che la richiesta venga ingiunta al Barone di Châtillon; 2 doc.; 1 sigillo].

17/6/1612, *Convenzione fra Paolo Emanuele Challant barone di Châtillon, signore d'Ussel e St-Marcel, e il signor Agostino Gromo da Biella e i signori Giovanni e Giuseppe Desio, padre e figlio, da Milano, per la quale detti Gromo e Desio potranno sfruttare direttamente la cava di manganese sita a Revers di Saint Marcel*, FC 343-18 [col sigillo del vescovo di Torino Broglia].

26/6/1612, *Atti seguiti avanti il Senato nella causa del Signor auditore Perrone contro Signor Paolo Emanuele di Challant, barone di Castiglione. Per sentenza deli 26 giugno 1612 è stato detto signor barone di Castiglione mantenuto nel possesso della cava del manganese*, FC 161-2B.

26/6/1612, *Sentenza del 26 giugno di 1612, dove si è pronunciato doversi mantenere il detto signor barone di Castiglione nel possesso della cava della predetta miniera del manganese*, FC 161-3.

26/6/1612, *Sumario nella causa del molto illustre signor Carlo Perrone San Martino contra l'illustrissimo signor Paolo Emanuel Chialant, signore di Castiglione*, AST SR, Perrone di San Martino, partizione 1, cartella 4, fascicolo 59 [A stampa. Il regesto sul dorso specifica: "Per fatto del manganese et acquisto della miniera nella montagna di Revers S. Marcello"].

5/10/1612, *Atti del processo tra Paolo Emanuele di Challant, barone di Châtillon, e Carlo Perrone di San Martino per la miniera di manganese di St-Marcel*, FC 165-8.

13/12/1612, *I maestri Vincenzo dal Todescho, Giovanni alla testa d'oro, Lodovico alla Luna e altri vetrai muranesi dichiarano di utilizzare circa 35 migliara di manganese all'anno e che questo minerale proviene dalle miniere di St-Marcel*, FC 161-6.

23/12/1612, *Il Duca ordina che la richiesta [del 17/6/1612] di Agostino Gromo, di Biella, e di Giovanni e Giuseppe Desy, di Milano, sia notificata al Barone di Châtillon*, FC 165-6 [2 doc., 1 sigillo].

1612, *Paolo Emanuele di Challant pervenuto all'età maggiore avesse per instromento 10 dicembre 1611 e 17 giugno 1612, quivi annessi, concesso alli predetti Gromo e Desio la ragione di estrarre nelle dette montagne alcune migliara di manganese, per il prezzo, patti e modi contenuti in detti instromenti*, FC 161-4B.

1612, *Progetto di transazione tra Paolo Emanuele di Challant e Carlo Perrone di San Martino riguardante la miniera di manganese di St-Marcel, venduta da Adriana Costa*, FC 165-29.

22/3/1614, *Copia di laudo tra il signor barone di Castiglione e signor Carlo Perrone San Martino per fatto del manganese*, AST SR, Perrone di San Martino, partizione 1, cartella 4, fascicolo 60.

22/3/1614, *Sentenza arbitramentale sulle differenze insorte tra il signor Paolo Emanuele di Challant, barone di Castiglione, ed il signor Carlo Perrone, d'Ivrea, circa il possesso che doveva continuare ad avere il detto signor barone della miniera del manganese, nonostante la vendita fatta al detto signor Perrone dalla dama di Castiglione*, FC 161-7.

1615-1619, *Registre du manganèse consigné au greffe de Châtillon pour les années 1615 à 1619*, FC 165-11.

1615-1619, *Registro del manganese registrato a Châtillon*, FC 165-15.

10/1/1615, *Lettres de Gaspard de Vilette au baron de Châtillon, touchant les minières de manganèse*, FC 165-4 [Gaspard de Villette était le beau-frère de Paul Emmanuel].

30/1/1615, *Lettre au baron de Châtillon, touchant les minières de manganèse*, FC 165-4.

12/4/1615, *Paul-Emmanuel de Challant ordonne à Michel Freidoz de délivrer à Antoine Venez 40 rups de manganèse à raison de trois sous le rup*, FC 165-10.

18/9/1615, *Lettera di Carlo Perrone sulle miniere di manganese*, FC 161-8.

10/12/1615, *Note du manganèse consigné au greffe de Châtillon du 27 août au 10 décembre 1615*, FC 166-1 bis.

6/4/1616, *Conti redatti tra il barone di Châtillon e Giovanni e Giuseppe Desio e gli eredi di Agustino Gromo*, FC 165-14.

1618-1620, *Maganese nel registro della baronia di Châtillon*, FC 165-17.

20/3/1618, *Il barone Paolo Emanuele di Challant, in considerazione delle spese sostenute da Giuseppe Desio, gli dona mille rubbi di manganese. L'estrazione è a carico di Giuseppe Desio*, FC 165-16.

23/4/1618, *Cessione fatta da Giovanni e Giuseppe padre e figliuolo Desii, dagli eredi del fu signor Agostino Gromo a favore del signor Carlo Perrone di S. Martino d'ogni ragione competenteli di estrarre nelle montagne delle giurisdizioni di S. Marcello la materia del manganese*, FC 161-4A.

28/1/1619, *Notta del manganese qual si riceve da San Marcello alli 28 Genaro 1619*, FC 165-12.

18th century, *Bozza di richiesta presentata al Duca di Savoia da Carlo Perrone in merito alle miniere di manganese di St-Marcel*, FC 165-31.

1621, *Atto della causa tra Marta Gromo, vedova di Agostino Gromo, e Giovanni Gattinara, relativa ai conti del manganese ricevuto da quest'ultimo*, FC 165-18.

9/10/1621, *Su richiesta del conte Carlo Perrone di San Martino, il duca di Savoia proibisce al barone di Châtillon di impedire lo sfruttamento della miniera di manganese di St-Marcel*, FC 165-19.

1622, *Notta del manganese [...] da San Marcello a nome dal Sr Perrone*, FC 161-10.

29/1/1624, *Sebastiano Gromo dichiara di aver ricevuto dal barone Paolo Emanuele Challant de Châtillon la somma di 54 scudi*, FC 161-9.

25/6/1628, *Testament de Paul-Emmanuel de Challant*, FC 15-3.

1632-1633, *Unitamente agli atti seguiti avanti la Camera ducale nella causa di detto signor barone Perrone, contro il sovranominato barone di Castiglione per il fatto del suddetto manganese, dal 1632 al 1633*, FC 161-4C [3 doc.].

20/10/1632, *Il duca Vittorio Amedeo di Savoia, su richiesta del barone di Châtillon, prese sotto la sua protezione coloro che verranno a lavorare nelle miniere di manganese di St-Marcel e permise loro di esportare questo minerale dal ducato d'Aosta senza dover pagare alcun dazio doganale*, FC 166-2 [1 sigillo].

20/12/1632, *Vittorio Amedeo, duca di Savoia, ordina al barone Perrone di essere presente al deposito e alla garanzia che il barone di Châtillon farà in base all'ordinanza della Camera per poter estrarre e vendere il manganese di St-Marcel*, FC 166-3 [2 doc.; 1 sigillo].

8/3/1636, *Il barone Perrone si rivolge al duca di Savoia affinché ordini al barone di Châtillon di non ostacolare più l'estrazione e l'esportazione di manganese da St-Marcel*, FC 165-21.

29/2/1640, *Copia di supplica autentica del conte di Challant, contro il barone Perrone il quale sotto pretesto d'esser creditore di certa somma verso il detto barone di Castiglione, fece trasportare grandissima quantità di manganese di S. Marcello, per farlo desistere di far cavare...; con l'ordine del duca Carlo Emanuele*, FC 166-4.

29/2/1640, *Petizione presentata al Senato Reale dal Barone di Châtillon de Challant, contro il Barone Perrone per impedirgli di lavorare o trasportare il minerale chiamato manganese*, FC 161-11 [2 doc.; 1 sigillo].

8/3/1640, *Le greffier de Châtillon donne le rapport de l'exploit fait contre le baron Perrone en faveur du baron de Châtillon. à l'égard de leur différend pour la minière de manganèse de St-Marcel*, FC 165-22.

11/3/1640, *Le comte Antoine Perrone de San Martino recourt à S.A. à l'égard des minières de manganèse de St-Marcel. Lettres du duc Charles-Emmanuel de Savoie sur ce fait*, FC 161-12 [2 doc., 1 sceau, écriture gothique].

1642, *Progetto di affitto delle miniere di manganese di St-Marcel, concesso dalla baronessa Leanza San Martino di Strambino, baronessa di Châtillon, ad Alessandro Salvay*, FC 161-13.

17th century, *Richiesta di Alessandro Orengiano per il processo tra Battista e Bernardino Cavallo contro la signora di Challant, in merito al manganese*, FC 165-33 [Documento incompleto, senza data].

5/5/1661, *Louis Réan, de St-Marcel, promet d'extraire pour le baron Perrone San Martino 4000 rups de manganèse des mines de St-Marcel et de conduire le minéral à Ivrée aux prix de 16 livres ducales chaque 40 rups*, FC 161-14.

11/9/1662, *À la requête de la comtesse Léance de Challant, Martin Vuillien déclare que de l'année 1638 à l'année 1642 il a fait conduire de St-Marcel à Ivrée, pour le baron Perrone, 120 milliers de manganèse*, FC 166-8.

1/3/1664, *Petizione presentata alla R. Camera dei Conti dalla contessa Prospera Perrone di San Martino, in qualità di madre e tutrice dei conti Carlo Filippo e Francesco Antonio, suoi figli, nonché del defunto Cesare Perrone, contro il barone Francesco-Girolamo di Challant di Châtillon e sua madre, la baronessa Leanza, che ritengono di avere il diritto di scavare e di estrarre il manganese dalla miniera situata nella montagna di St-Marcel*, FC 161-15.

10/3/1670, *Rendiconto del capitale e degli interessi che il barone di Châtillon deve pagare agli eredi di Antonio Perrone, in base al lodo arbitrale del 22 marzo 1614*, FC 162-4.

12/3/1670, *Règlement des comptes entre le baron de Châtillon et les héritiers d'Antoine Perrone à l'égard des minières de manganèse de St-Marcel*, FC 165-23 [in French and Italian].

1670, *Atti vertiti avanti il Real Senato di Torino tra il signor barone Francesco Girolamo di Challant contro il signor conte Carlo Filippo Perrone, per farlo condannare alla remissione della miniera da lui occupata, detta del manganese, nel monte di St. Marcello*, FC 162-3 [1 sigillo].

17/6/1670, *Per ordinanza delli 17 giugno 1670, si è ridotta l'ammissione in possesso per il detto signor barone di Challant [...] e si è mantenuto li predetti signori fratelli Perrone nel possesso della montagna suddetta*, FC 162-5.

21/6/1670, *Francesco Crosa, Vitallo Treves, Abraham Maimone, Giuseppe Maria Pissana e Lorenzo Robella, tutti torinesi, dichiarano di aver acquistato alcune quantità di manganese dalle miniere di St-Marcel, vendute dai baroni Perrone*, FC 161-16.

18/12/1670, *Antonio Sculdo, verriero di Leinì, attesta di aver acquistato del manganese a Ivrea, ma di non conoscerne l'origine*, FC 161-17.

31/12/1670, 1/1/1671, *Les particuliers de St-Marcel témoignent pour le baron de Châtillon d'avoir conduit du minéral de manganèse à Ivrée pour le comte Perrone*, FC 161-18.

2/1/1671, *Antonio Casca, di Ivrea, dichiara di aver acquistato dal barone Antonio Perrone alcune quantità di manganese*, FC 161-19.

2/1/1671, *Sebastiano Costa, di Ivrea, dichiara di aver acquistato del manganese dal procuratore della baronessa Perrone di San Martino e di averlo pagato 21 o 23 soldi per rubbo*, FC 165-24.

22/5/1671, *Francesco Girolamo di Challant, barone di Châtillon, vende ad Antonio Piana di Ivrea 1300 rubbi di manganese da estrarre dalle miniere di St-Marcel al prezzo di 11 soldi e mezzo per rubbo*, FC 161-1C.

15/6/1671, *Transazione seguita tra il signor Francesco Girolamo di Challant, barone di Castiglione [...] da una parte, e la signora contessa Prospera Perrone S. Martino di Bellagarde, nella qualità di madre, tutrice e curatrice dei suoi figliuoli, in seguito alle differenze e lite tra essi vertita per riguardo alla montagna e miniere del manganese*, FC 162-6.

9/2/1673, *François-Jérôme de Challant, baron de Châtillon, donne la permission à Pierre Pasquier de St-Marcel d'extraire du manganèse aux minières de St-Marcel pour être porté à Aoste ou à Châtillon, moyennant la somme de trois sous pour chaque rup*, FC 166-9.

9/3/1673, *Francesco Girolamo di Challant promette di vendere a Carlo Francesco Antonietto, a Ivrea, mille rubbi di manganese di St-Marcel al prezzo di 16 soldi il rubbo*, FC 166-10.

9/5/1681, *Il barone Francesco Girolamo di Challant vende a Giovanni Antonio Piana di Ivrea 3000 rubbi di manganese di St-Marcel, da estrarre a spese dell'acquirente, al prezzo di 10 soldi e 6 denari per rubbo*, FC 166-14.

12/9/1681, *Le baron François-Jérôme de Challant établit une convention avec Pierre Pâquier et Marcel Ferraz, de St. Marcel, pour l'extraction du manganèse de St-Marcel et la conduite du minéral à Aoste, Châtillon ou Ivrée*, FC 161-1D.

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Tiratura: 300 copie
Formato: 17x24 chiuso
Copertina: stampa in quadricromia
su carta Splendorgel EW gr 350 più plastificazione opaca
Interni: stampa su carta patinata opaca da gr 115
Le carte utilizzate sono prodotte nel pieno rispetto del patrimonio boschivo

Finito di stampare nel luglio 2026
tramite Ledizioni-Milano

Accademia
delle Scienze
di Torino
1783

The Praborna manganese mine, in Italy's Aosta Valley, was first documented in 1402 and remained in use until 1903. For centuries, its ore was highly valued by the glassmakers of Murano, near Venice, who used it to produce the famous *cristallo veneziano* – the brilliant transparent glass that became a symbol of luxury during the Renaissance. By adding manganese oxide to the molten glass, the glassmakers cancelled out the greenish tint caused by iron, creating a material of exceptional clarity. This technology contributed to the production of mirrors, luxury artefacts and even the transparent lenses used by Galileo for his telescopes. From Venice, the technique spread across Europe, playing a key role in shaping the history of early modern glassmaking.

Praborna is also renowned for being a classic occurrence of alpine mineralogy. Its manganese-rich oceanic rocks were metamorphosed at great depths and host a remarkable variety of rare minerals, including piemontite, roméite, violan and alurgite, alongside braunite, manganiferous garnets, pyroxmangite, hausmannite, tephroite, rhodochrosite and rare-earth minerals. Today, Praborna is a unique open-air museum that reveals the interrelated histories of mineralogy, mining and glass manufacturing.

Euro 25,00

ISSN: 1125-0402; ISBN: 987-88-99471-63-7